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ABSTRACT

This report describes a federally funded project to study integration of computers into the writing instruction of classroom teachers, and evaluates the impact of a computer-supported writing program on instruction, on the writing process, and on products of normally achieving and learning-disabled (LD) students. The study compared the impact of a computer-supported versus pencil-and-paper writing process program on students' writing quality and attitudes. The study involved 62 fourth-grade students in treatment classrooms using computers, 16 of whom were LD students, and 65 students in comparison classrooms not using computers, 13 of whom were LD students. Results showed modest support for a computer-supported writing environment. The computer, in combination with an instructional approach that emphasized extensive composing, revising, and individualized help, contributed to gains in writing quality. Experimental students reported a greater enjoyment of writing at the end of the study year than they reported at the beginning. (JDD)

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THE IMPACT OF COMPUTER-SUPPORTED WRITING INSTRUCTION ON THE WRITING QUALITY OF LEARNING-DISABLED STUDENTS

FINAL REPORT

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EXECUTIVE SUMMARY

INTRODUCTION

Over the last decade, teachers, specialists, and researchers have been intrigued with the potential power of the computer to enhance learning disabled (LD) students' writing process and written products. The computer's editing and revising features and the readable, professional-looking text were thought to ease handwriting and rereading problems, to help others read and respond to LD students' work, and to strengthen LD students' desire to write and revise.

With funds from the U.S. Office of Education, Division of Special Education Programs, EDC embarked in 1984 on a two-year study of how resource room teachers were using computers with LD students. Encouraged by these early results, the project expanded into mainstream classrooms with a two-year investigation of how classroom teachers can integrate the computer into writing instruction for their whole class. Our major goals were: (1) learning what is required for classroom teachers to implement a computer-supported writing program successfully, and (2) learning what impact a computer-supported writing program has on teachers' writing instruction and on the writing process and products of normally achieving and learning disabled students.

In the first year, project staff worked closely with teachers to help them implement a computer-supported writing program. By the second year, all classrooms had integrated word processing into their writing programs. Each used a systematic approach to train students in keyboarding and word processing skills prior to using the computer for composing. Nevertheless, the classrooms varied somewhat in their levels of implementation of the computer-supported writing process approach. That is, students received more feedback from peers, more support for elaborating and revising their writing, and more individualized help in some classrooms than in others. In the second year, the project selected a set of comparison classrooms in order to assess the impact of the program. In both treatment and comparison classrooms, project staff carried out repeated assessments of students' writing quality through gathering writing samples. In addition, pre/post questionnaires were used to assess attitudes about writing. The project followed sixteen LD students in the computer-supported classrooms through intensive observation, collection of writing products, and teacher interviews.

Background

Theoretical support for the benefits of the computer as a writing tool for LD students stems from two areas. Cognitive processing theories suggest that the computer may ease the processing

demands of writing for the LD student. For example, the electronic typing features may alleviate the student's need to attend to the physical demands of producing clear and legible handwriting. And the visibility of the text to the writer may ease the task of self-monitoring--an area of reported special difficulty for LD students. Finally, the mechanical demands of producing text should be eased, freeing the student's attention for monitoring and higher level writing processes. Coupled with writing instruction that is particularly appropriate for LD students, the computer might especially facilitate content revision for this population. Social context theories suggest that the "interactive" features of the computer may facilitate the kinds of teacher/student and peer collaboration that contribute to more fluent generating and expressing of ideas. The interactive features of the computer may be particularly valuable to the LD student if they facilitate rereading and self-monitoring and if they enable the teacher to intervene earlier in the LD student's writing process.

While many special features of word processors are promising for LD students, they are most likely to make a difference in LD students' writing when coupled with good writing instruction. Until the present study, no research has looked systematically, over an extended period of time, at the impact computers might have on LD students' writing process and written products in a context in which they are receiving sustained writing process instruction.

Purpose

The purpose of the present study, then, was to integrate word processing into classrooms with excellent writing process programs, and then to observe whether those programs enhanced students' ability to manage the writing process, writing quality, and attitudes towards writing. We conducted an intensive observational study of the treatment classes in both Years 1 and 2, and a comparative study of the impact of computer-supported versus pencil-and-paper on students' writing quality and attitudes in Year 2. This report presents only the results of our Year 2 comparative study. For this study we assessed the quality of students' writing at four points during Year 2 and obtained pre-post measures of students' self-perceptions and attitudes toward writing in the treatment and comparison classes. This report is organized around three program impact questions:

1) Do fourth-grade students in a computer-supported versus paper-and-pencil writing process program differ in relation to narrative writing quality, self-perception, and attitudes toward writing?

2) Do LD versus non-LD students in the two different kinds of programs differ in the quality of their writing, self-perception, and attitudes toward writing?

3) Do LD students in a computer-supported writing environment versus paper-and-pencil writing program differ in writing quality, self-perception, and attitudes toward writing?

METHODS

Site Selection/Sampling

Three research districts included Brown, an ethnically diverse small city with families of low-average to high incomes; Carver, an affluent, mostly white suburb; and Waverly, an ethically diverse small city of low- to middle-income families. In Year 1, four treatment classroom teachers were selected within three schools to participate in the project. Each had at least three years' experience with a writing process approach at the fourth-grade level, had access to computers for all students two to three writing periods a week, were identified as excellent teachers by their peers and administrators, and had at least four moderately LD students mainstreamed in their classrooms.

In Year 2, the treatment teachers continued to participate, and comparison teachers were selected in each site. The same criteria were used as for the treatment teachers except that the comparison teachers were not using computers to teach writing. To monitor comparison teachers' instructional approach, we interviewed each prior to the onset of the study and collected a sample of three students' writing for each of their writing assignments throughout the year.

The study included a total of 62 students in the treatment classrooms, 16 of whom were LD students. It included 65 students in the comparison classrooms, 13 of whom were LD students. Criteria for identifying LD students included:

- ranking in the fourth quartile in a National Assessment of Educational Progress (NAEP) writing assessment conducted by EDC Writing Project staff in the fall of each year
- evidence of average or above-average IQ on student record data on cognitive skills
- evidence of written language achievement patterns that were at least one year below current grade level
- no evidence of another major disability

- evidence that teachers and specialists had identified the student as having mild to moderate learning problems.

LD students varied in their constellation of writing strengths and weaknesses and general learner characteristics.

Materials/Equipment

All of the treatment students wrote on Apple II-e or Apple GS computers and used either Bank Street Writer (Broderbund, 1984), Bank Street Writer III (Scholastic, 1986) or Magic Slate (Sunburst, 1984). In Year 2, all three treatment classrooms used a word processing curriculum developed collaboratively by the EDC research staff and the Brown classroom teachers and computer specialist during the preceding summer.

Instruments

Stimuli and procedures from the National Assessment of Educational Progress (NAEP) were used to gather four samples of students' writing over a nine-month period. The Self-Perception Profile for Children (Harter, 1985) was used to measure pre-post changes in students' self-perceptions. A Student Writing Questionnaire was developed by EDC staff to assess children's perceptions about themselves as writers.

Data Collection

Classes participated in the study from September to May, with treatment classes carrying out their writing with paper and pencil from September through November while they acquired basic keyboarding and word processing skills. In early December, treatment teachers began integrating word processing into their writing programs. From January through May, students wrote on the computer three times per week for approximately 30-40 minutes and additionally used the computers during free time. Systematic weekly observations were conducted in each treatment class, during which observers documented the teacher's introductory instruction and then observed two selected LD students alternately over the rest of the class period.

Data Analysis

A total of 554 writing samples from treatment and comparison classes were scored by 16 teachers trained by the Principal Investigator and Research Associate in applying the National Assessment of Educational Progress (NAEP) primary scoring guide for imaginative narrative writing. The study used growth

modeling, in addition to traditional gains-score and repeated measures analysis, to assess change in students' writing quality over the four NAEP assessments.

TREATMENT

The project identified five critical components of a "computer-supported writing program" most likely to benefit both normally achieving and learning disabled students, including:

- an approach to writing instruction that reflects basic principles of a writing process approach
- regular access to the computer for writing
- full integration of the computer into varied writing activities
- a strong knowledge of machine skills, by both teachers and students
- the availability of individualized help for special needs students within the mainstream writing program

The project made every effort to maximize these components in the treatment classrooms, through selecting teachers, working with systems to maximize computer access, developing a machine skills curriculum, and providing curriculum resource materials. Although the four classrooms reflected all five general elements of a computer-supported writing program, they varied in the level at which they implemented some of the elements. For example, Brown and Carver differed from Waverly in carrying out long-term writing projects for which students were extensively prepared, and in directly teaching skills and strategies related to the craft of composing and revising. Both the Brown and Carver teachers created a pervasive atmosphere of generating and sharing ideas and texts, and intimate opportunities for talking about writing. The main difference between the Brown and Carver classrooms lay in the greater opportunity Brown LD students had for sharing their writing and in the systematic feedback they received around highly individualized writing issues.

RESULTS

The site-by-site analysis focused first on the impact of the classroom writing programs on the writing quality of all students. There are several indicators that students in Brown's computer-supported classroom increased their writing quality over the school year more than students in the Brown paper-and-pencil classroom. The overall growth rate for the treatment classroom

was significantly higher than that of the comparison classroom, using a growth-model analysis. (A traditional gains-score analysis also supported that result.) In Carver, the results also favored the computer-supported classroom over the paper-and-pencil classroom. Though the growth rate of the Carver treatment class was not statistically different from that of the Carver comparison class, students in the Carver treatment classroom grew the most, over the four assessment points, of all of the treatment and comparison classrooms. There were no differences between the treatment and comparison classrooms in Waverly.

The second focus of the analysis was on the difference between LD and non-LD students across treatment and comparison classrooms in each site. In all three sites, the LD students initially performed at a significantly lower level than did non-LD students. However, LD students' growth rates were not different from the growth rates of the non-LD students.

The third focus of the analyses was on the differential impact of the writing programs on LD students in the treatment classrooms versus LD students in the comparison classrooms. In Brown, we observed some differences in the growth rate of LD students in the treatment and comparison classrooms. Though the small sample did not yield statistically significant results, analysis of the unadjusted data revealed practical differences between the two groups, with the growth rates of the LD students in the computer-supported classrooms exceeding the growth rates of the LD students in the paper-and-pencil classrooms. LD students in Carver and in Waverly achieved similar rates of growth in the treatment and comparison classrooms.

In all three of the computer-supported classrooms students reported a greater enjoyment of writing at the end of the year than they reported at the beginning. In Brown and Waverly, the percentage of students in the treatment classes who increased their enjoyment of writing was more than twice the percentage who increased their enjoyment in the comparison classes. In Carver the percentage was comparable in treatment and comparison classrooms. In Brown and Waverly, the percentage of students who increased their perceptions of how "good" they were at writing was more than twice that of the percentage of comparison students. The relationship in Carver was reversed, with more Carver comparison students demonstrating an increase. Across all sites, treatment students in the computer-supported classrooms perceived themselves writing less by the end of the year than did comparison students. This finding holds for LD as well as non-LD students.

Three of the five LD students in the Brown computer-supported classroom increased their enjoyment of writing and their rating of how good they are in writing; in contrast, none of the LD students in the Brown comparison classroom increased either their

enjoyment of writing or their perception of being a good writer. None of the LD students increased their enjoyment of writing in Carver and Waverly, while two Carver and one Waverly LD students in the comparison classrooms did increase their enjoyment.

Across all three sites, more than 55 percent of the students in each treatment class rated the computer as helpful in writing a first draft and over 60 percent rated the computer as helpful in revising and editing. Fifty percent of the Brown treatment students and 75 percent of Carver treatment students found the computer helped them with carrying out peer conferencing; under 10 percent reported this in Waverly, where peer conferencing received much less emphasis. Over 60 percent of Waverly students, many of whom had used spell checking, rated the computer as helpful in their spelling.

DISCUSSION

The results from Brown and Carver show modest support for a computer-supported writing environment. It appears that the computer, in combination with 1) an instructional approach that emphasizes extensive composing and revising, and 2) individualized help for LD students, contributes to gains in writing quality. This interpretation offers a reasonable explanation for both the differences between the Brown treatment and comparison classrooms and the differences between the Brown and Carver results. In Brown, both treatment and comparison teachers were highly experienced writing teachers and used similar approaches--they were well matched for the purposes of the study. The major difference between the two was the writing tool, which in the treatment classroom enabled students to take full advantage of the extensive emphasis on composing and revision. Observation data document the treatment teacher's succession of mini-lessons on expanding and revising students' drafts and verify that students took advantage of this targeted approach to elaborate and revise their writing over many drafts. The students in the treatment classroom had a tool that enabled them to take greater advantage of the revision instruction provided them. In contrast, the ability of the comparison students to revise their writing was limited by the necessity of recopying their drafts.

The availability of individualized help in the Brown treatment classroom further enhanced the LD students' ability to take advantage of an emphasis on expansion and revision. The combination of explicit feedback on their writing, a person to provide additional guidance when needed, and a writing tool to facilitate making changes probably all contributed to the higher level of growth in the treatment class in general and to the higher level of growth in the treatment LD students than in the comparison LD students.

The Carver site showed a similar pattern to that of Brown, although it was not statistically significant. Treatment students at Carver showed the highest final scores in the NAEP assessment and the greatest change from the first to the fourth assessment. The absence of any impact of the computer-supported writing approach in Waverly on student writing quality may possibly be attributable to the use of an instructional method in both treatment and comparison classrooms that was not particularly enhanced by the use of computers. Though both Waverly teachers in the treatment sample used elements of a "process" approach, their writing assignments tended to take the form of brief writing activities. They also employed less extensive composing, sharing, collaborating, and revising than we observed in the Brown classrooms and the Carver treatment classroom. In addition, the teachers provided less direct instruction in revision than did the Brown and Carver teachers. And the kind of revision students carried out, which generally took the form of substituting more descriptive words or editing for spelling and mechanics rather than elaboration or meaning changes, might be as easily managed with paper and pencil. The results of pre/post attitude assessment raise several questions. Why did Brown treatment students (including LD students) and Waverly treatment students increase their enjoyment of writing and their perception of themselves as "good" writers more than the comparison students, while students in the Carver classroom did not? And why do students across all three computer-supported classrooms perceive themselves as writing <u>less</u> than students in paper-and-pencil classrooms? This latter finding was as true in Brown, where students were actually composing twenty-page autobiographies and in Waverly, where students were often composing a single paragraph. It may be that the presence of the computer stimulates additional revision, giving students the sense that they are working on one piece of writing extensively, rather than producing a great deal of new text. Or perhaps students equate writing with the physical act of putting pen to paper.

This research is developmental in nature: we are still generating knowledge about the kinds of instruction and interventions that benefit LD writers. Therefore, it will be important to look further at the variation within the LD group. Data gathered through observations of LD students, writing samples, and interviews with classroom and remedial teachers about the LD students in our sample need a great deal of further analysis in order to illuminate the differences between the LD students who grew in the computer-supported writing classrooms and those who did not. For that analysis, we will be exploring several preliminary hypotheses about the interaction between specific LD writing problems and the writing tool. We will also be investigating specific factors that may contribute to LD

students' enjoyment of writing and their perceptions of themselves as writers.

In conclusion, the study provides modest though promising indications that the computer may play a highly supportive role in the context of certain kinds of writing instruction. Where students are working with longer pieces of writing over time, receiving ongoing instruction in the craft of writing, and receiving specific appreciation and response to their writing from peers and the teacher, the computer may be an ideal writing tool. Writing becomes less a linear process of drafting, revising, and recopying than a series of encounters that move back and forth among several processes--elaborating, revising, and more mechanical levels of editing.

I: INTRODUCTION

The accelerating trend toward educating handicapped children in mainstream classrooms poses an enormous challenge to the classroom teacher. The group that is increasing most rapidly consists of school identified learning disabled (LD) students, who possess the intellectual potential to succeed in school but whose problems with reading, writing and mathematics substantially hamper their learning. Nowhere is the problem more poignant than in writing, the single most common problem of LD students in the 9- to 14-year-old range (Moran, 1981; Poplin, 1983; Wiig & Semel, 1976). Teachers find that LD students write much less than their peers, can usually tell more about a topic than they can write, revise less, and have problems with legibility, spelling and mechanics (Englert et al., 1988; Graham & Harris, in press; Graham & MacArthur, 1987; Morocco, 1987; Myklebust, 1973; Nodine, Barenbaum & Newcomer, 1985; Poteet, 1978; Thomas, Englert & Gregg, 1987). At the point where they need to be able to use writing to learn and express their ideas across a variety of subject areas--fourth grade--LD students begin to diverge from their peers in writing ability.

Over the last decade, teachers, specialists, and researchers have been intrigued with the potential power of the computer to support and enhance LD students' writing process and written product. The computer's editing and revising features and the readable, professional-looking text were thought to ease handwriting and rereading problems, facilitate others' reading and response to LD students' work and increase students' motivation to write and revise. With funds from the U.S. Office of Education, Division of Special Education Programs, EDC embarked in 1984 on a two-year investigation of how teachers were using resource room computers with LD students. The project was encouraged by teachers who were integrating the computer into a "writing process approach." These teachers were engaging

students in composing and revising texts rather than practicing isolated writing, grammar and mechanics exercises. The results of this study are presented in Morocco, 1987, and Morocco and Neuman, 1988. As a result of these encouraging trends, the project expanded the research into mainstream classrooms, where LD students spend most of their writing time, with a two-year investigation of how classroom teachers can integrate the computer into writing instruction for their whole class. While our first concern was for LD writers, we assumed that teachers and administrators would expand their use of computers in mainstream writing programs only if they enhanced the writing process of all students. As a result, our major goal encompassed learning what is required for classroom teachers to successfully implement a computer-supported writing program, and learning what impact a computer-supported writing program has on teachers' writing instruction and on the writing process and products of normally achieving and learning disabled students.

In Year 1 of the current study, the project was carried out in three schools, in three different communities, within four fourth-grade classrooms. The teachers were identified by language arts specialists in those communities as excellent writing teachers who were also beginning to use computers in their writing programs. In the first year, the project worked closely with teachers to help them implement a computer-supported writing program. By the second year, all classrooms had integrated word processing into their writing programs. Nevertheless, the classrooms varied somewhat in their levels of implementation of the computer-supported writing process approach, in that students received more support for revision and more individualized help in some classrooms than in others. In the second year, the project selected a set of comparison classrooms in order to assess the impact of the program. The quality of all students' writing was evaluated through repeated assessments of students' writing samples and their attitudes

about writing, in both treatment and comparison classrooms. The project also followed sixteen LD students through intensive observation, collection of writing products, and teacher interviews.

In this report we present the results of the study, addressing three major questions: 1) Do fourth-grade students in a computer-supported versus paper-and-pencil writing process program differ in relation to narrative writing quality, self-perception and attitudes towards writing? 2) Do LD versus non-LD students in the two different kinds of programs differ in the quality of their writing, self-perception and attitudes toward writing? and 3) Do LD students in a computer-supported writing environment versus paper-and-pencil writing program differ in writing quality, self-perception and attitudes toward writing? We also examine how varied features of the computer-supported writing programs may contribute to differential impact on students' writing quality. Other continuing analyses will draw on case-study data to describe how teachers modified their computer-supported writing programs to meet individual LD student needs.

BACKGROUND

The study builds on three streams of prior research: writing and what constitutes effective writing instruction, the writing and general learning problems of LD students, and the impact of computers on writing.

Research on Writing and Writing Instruction

A view of writing as an interrelated set of motoric, cognitive and social processes has emerged from over a decade of intensive research on how children and adults write. Developing some level of automaticity in basic motor skills, as well as language

skills, is essential if students are to be able to use writing to express their ideas (Denckla & Rudel, 1976). Motor control also plays a critical role in the consistent forming of letters and words and the spacing of writing on a page, all of which are crucial to legibility.

Flower and Hayes (1981a, 1981b; see also Hayes & Flower, 1980) and Bereiter and Scardamalia (1982) have contributed a view of writing as a set of thinking processes that include planning, composing and revising. During planning, writers establish their purpose for writing, generate ideas, focus their topic and consider their audiences' needs. During composing, writers translate thoughts into writing and generate new ideas as they read and reread what they have written (Britton et al., 1975). In composing, the writer has to integrate several kinds of knowledge about language: semantic knowledge in choosing which words to use, content knowledge, syntactic knowledge, pragmatic knowledge about effective ways to communicate this message to the audience, and knowledge of the writing conventions in the "writing community." During revising, the writer reviews and evaluates writing in terms of his purpose for writing and the knowledge and standards for "good" writing. These three phases are recursive--experienced writers move back and forth among planning, composing and revising many times in writing a single piece. The challenge of writing for even the most experienced writers lies in allocating attention to the multiple demands of the writing process in an appropriate and effective way. Flower and Hayes (1977) characterize this process of managing the task demands during writing as similar to the job of a switchboard operator--balancing the needs of several parties simultaneously.

Writing is a social as well as a cognitive process (Rafouth & Rubin, 1988). Studies of teacher and peer response to writing and studies of direct collaboration in writing draw on Vygotsky's general theory (1978) that successful collaboration stimulates

external teaching and learning processes that the child eventually internalizes and uses independently. Collaboration must be developmentally appropriate, within the "zone of proximal development" in Vygotsky's terms (1978, p. 85). When a reader or listener gives a child feedback about gaps or inconsistencies in a story, and the child is developmentally able to consider a reader's needs, then the child may not only review the text but also internalize the kinds of information readers may need in order to understand a story (Freedman, 1987, pp. 7-8). Freedman (1987) and Daiute and Dalton (1988) point to other areas of research and theories that support the impact of collaboration in learning, including talking about learning tasks (Johnson & Johnson, 1979); scaffolding--interactions that help a less experienced learner manage a complex learning process (Applebee and Langer, 1983; Applebee, 1981); reciprocal teaching--involving tutors who gradually release control to the student (Brown, Palinscar & Purcell, in press; Palinscar & Brown, 1984); procedural facilitation--providing procedures to facilitate writing (Morocco & Neuman, 1988; Bereiter & Scardamalia, 1982); and collaborative writing--experiences which "offer writers the chance to act as writer and reader out loud with the aid of a partner" (Daiute & Dalton, 1988, p. 251). All of this work supports the importance of creating a writing environment in which sharing and talking about writing is an ongoing, integral aspect of classroom life.

The emergence of a view of writing as a socio-cognitive process rather than a hierarchical set of writing skills acquired in isolation from composing meaningful texts has a far-reaching impact on the way writing is taught in schools. Several principles of good writing instruction have emerged from the research just discussed and also from a body of classroom-based, observational studies of teachers and children carrying out writing activities (Graves, 1983; Calkins, 1986; Englert et al., 1988; Englert & Raphael, in press; Langer & Applebee, 1986;

Bereiter & Scardamalia, 1982). These include, for example:

- engaging students in the full composing process, including planning, composing, sharing, revising and editing a text.
- promoting students' sense of ownership of their writing by providing opportunities for them to develop what they want to say around self-chosen topics.
- engaging students in writing that has a real intent to communicate--to themselves or to others.
- encouraging students to develop fluency in expressing their ideas before focusing on extensive revision and editing.
- helping students develop skills in listening and responding to each other's work at various stages of the writing process.
- helping students acquire specific procedures and strategies for managing the complex demands of planning, composing and revising. Provide them opportunities to internalize these procedures and use them independently.
- providing students information about the text structure and key features of the kinds of writing they will be undertaking.
- teaching students the spelling, mechanics and formatting conventions of their "writing community." Gradually increase students' responsibility for applying these skills in their own writing once they have developed what they want to say.

The goal of a writing process approach is for students to develop their ability to plan, generate, and express ideas, and revise and edit writing that is meaningful to them, and to carry out these processes on a social context in which students offer authentic responses to one anothers' writing.

While there is strong theoretical and research support for these principles in the writing community, teachers may find it challenging to apply them to the writing problems of learning disabled students.

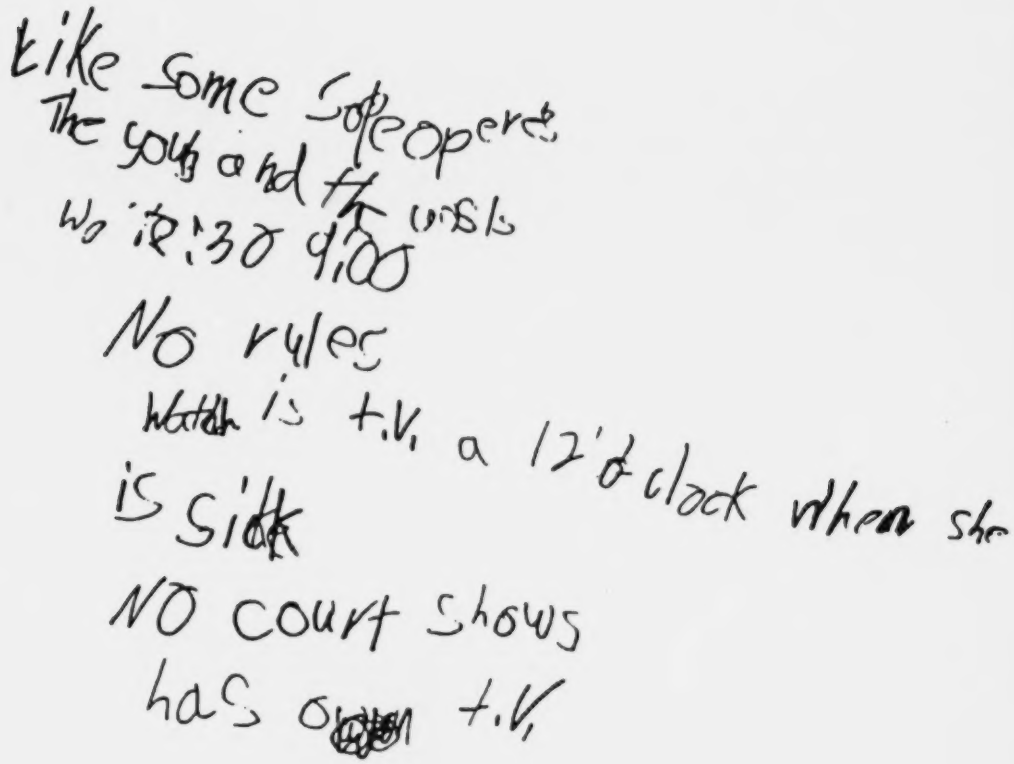
Writing Problems of LD Students

LD students have varied constellations of writing problems that span the motoric, cognitive and social aspects of writing discussed above. Some LD students' writing difficulties are mainly or in part motoric--handwriting problems that interfere with their writing fluency and with others' reading and responding to their ideas. The example in Figure 1 indicates motoric difficulties as well as other difficulties.

Other LD students appear to have difficulty managing the cognitive process required in writing. Some characteristics of LD writers particularly interfere with planning and generating ideas for writing. For example, some students have special difficulty accessing information that is relevant to a topic (Englert et al., 1988; Morocco, 1987; Morocco & Neuman, 1988), and a tendency to approach writing as a test-taking activity rather than as a communicative activity requiring planning and reflection (Thomas, Englert & Gregg, 1987). Some LD students can talk about their topics much more easily than they can write about them (Morocco, 1987; Englert et al., 1988). LD students may be less aware of text structures--what makes a fairy tale different from a fable--and other organizing structures in text (Englert & Thomas, 1987; Nodine et al., 1985; Thomas, Englert & Gregg 1987). Add to these problems the difficulty many LD students have in staying focused on the writing task (Neale, Cushman & Packard, 1985) and getting back on track if they lose their train of thought, and it is not surprising that they tend to write shorter and less complete pieces than non-LD students (Nodine, Barenbaum & Newcomer, 1985; Graham & Harris, in press; Graham & MacArthur, 1987; Myklebust, 1973; Poteet, 1978; Thomas, Englert & Gregg, 1987). The examples in Figures 2 and 3 illustrate LD students' difficulty in generating substantial and coherent text in response to a writing stimulus asking them to generate a story.

FIGURE 1

EXAMPLE OF MOTOR DIFFICULTIES OF SOME LD STUDENTS



Alex, grade 4

FIGURE 2

EXAMPLE OF LD STUDENTS DIFFICULTY IN GENERATING TEXT

Here is a picture of a girl who is having fun in the summer. Look at the picture for a while. What do you think she is doing? What do you think she might do next?

Write a story that tells what the picture is about. The girl is reching for a leaf for a fireflies.

June, grade 4

FIGURE 3

EXAMPLE OF LD STUDENT'S DIFFICULTY IN GENERATING TEXT

When you come home from school one day, you find a key on the table. Beside the key is a note addressed to you. The note says:

This key unlocks something
very special and unusual.

Write a story about your adventures with this special key.

This key will open up a box that haves thousand Dollar. The thousand Dollar is real and toy

Jason, grade 4

Other characteristics of LD writers may contribute to breakdowns in revision processes. Some studies find that LD students revise less (Thomas, Englert & Gregg, 1987). It is well documented that LD students have more difficulty with spelling and mechanics than other students (Deloach et al., 1981; Deno, Marston & Mirkin, 1982; Hemereck, 1979; Poplin et al., 1980; Poteet, 1978). When they revise they tend to focus primarily on mechanics (Loper & Murphy, 1985), although the explanation for this is not obvious. It could be that they have more mechanical errors than other students or that they have been trained in remedial sessions to focus mainly on spelling and mechanics, or because they actually have difficulty focusing on higher level writing issues. Deshler (1978) found that LD students did not monitor or correct potential confusions in their own texts nor in the texts of other people and tended to be more dependent on teachers to monitor the completeness of their compositions (Bos & Filip, 1984; Englert, Raphael & Anderson, 1986).

Very little research has looked at LD students' <u>social</u> interactions with other students during writing. Several studies of LD students' pragmatic, oral communication skills outside the writing context (Bryan et al., 1976; Bryan & Pflaum, 1978; Donahue, Pearl & Bryan, 1980; Olsen, Wong & Marx, 1983; Knight-Arest, 1984) suggest that some LD students might encounter difficulty collaborating with other students to expand and improve their writing. Teachers report that their LD students' anxiety during actual composing gets expressed in students frequently jumping up from their desks or copying other students' work (Neale, Cushman & Packard, 1986). Helping LD students develop a positive image of themselves as authors may be a more challenging job for teachers than is helping normally achieving students, since repeated difficulty in the early grades can lead to a perception of themselves as poor writers and thinkers by the time they reach the upper elementary grades.

Figure 4 reflects the work of a fourth-grade student with multiple writing difficulties, including a poor self-image as a writer and enormous frustration during actual writing. In this letter he has repeated a single idea several times ("I like to throw snowballs"), has crossed out and written over words, and shows difficulty with spelling and mechanics.

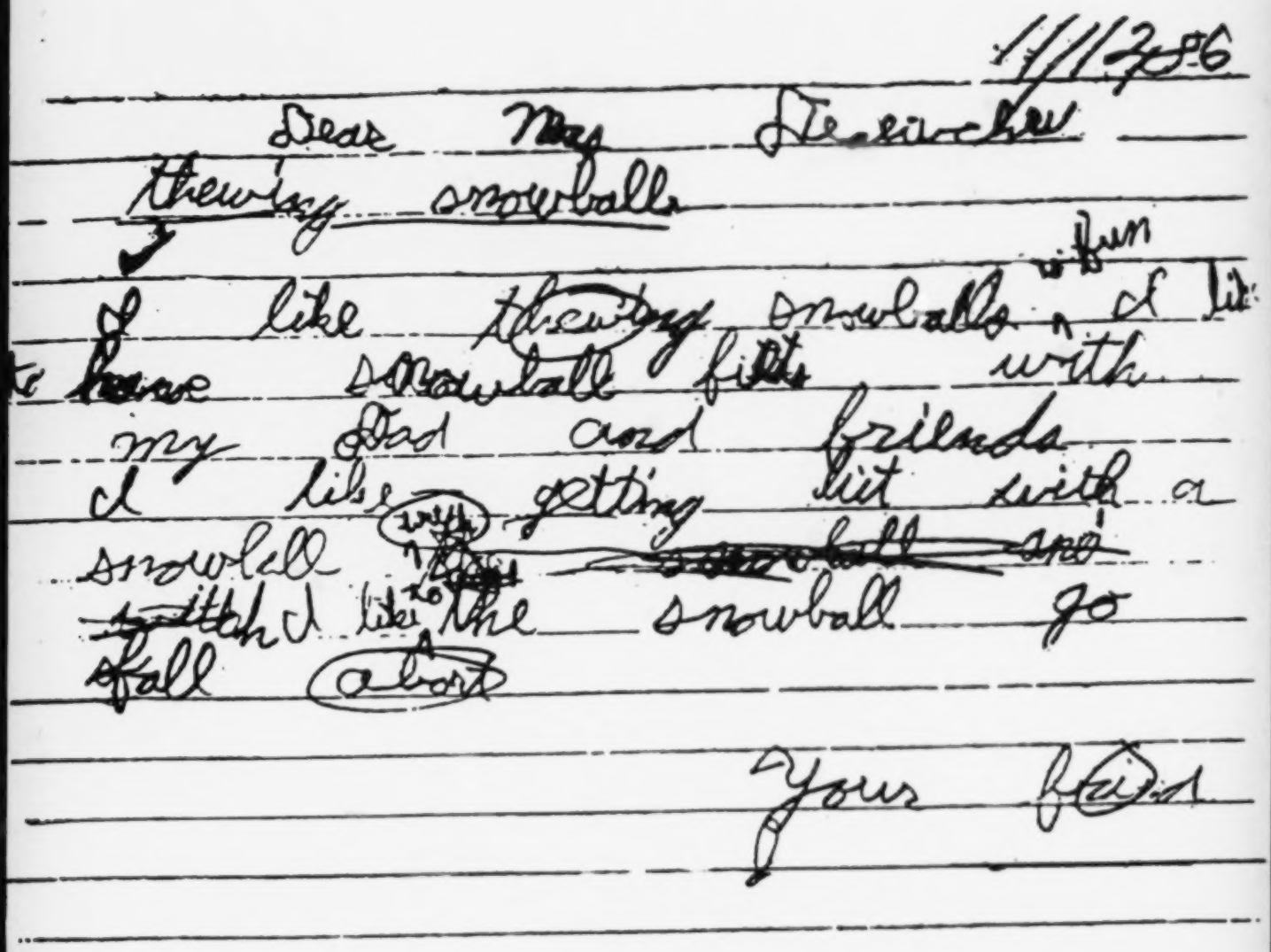
Managing all of the thinking and social processes required in writing is a challenge to the most experienced writer. LD students have particular difficulty balancing the many demands of the writing process. They evidence less spontaneous metacognitive behavior--awareness of their own cognitive and learning activities (e.g. Palinscar & Brown, 1984; Loper & Murphy, 1985). They may have more difficulty than their peers with what Flower and Hayes (1981a) call the "executive function" in writing: deciding when it is useful or appropriate to plan, compose or revise, and moving between those processes.

LD Students and Word Processing

Potential benefits of the computer as a writing tool for LD students stem from two lines of theory discussed above: cognitive processing and the social context of learning. In terms of cognitive processing theories, the computer may ease the processing demands of writing for the LD student. The electronic typing features of word processing alleviate the student's need to attend to the physical demands of clear and legible handwriting. The visibility of the text to the writer may ease the task of self-monitoring--an area of special difficulty for LD students. Finally, the mechanical demands of producing text should be eased, freeing the student's attention for monitoring and higher level writing processes (Goldman & Pellegrino, 1987). All of these benefits assume that students are using the computer in the context of writing instruction that guides them in what to monitor and engages them in reflecting on their writing.

FIGURE 4

EXAMPLE OF AN LD STUDENT WITH MULTIPLE WRITING *DIFFICULTIES*



Aaron, grade 4

The revision features of the computer--allowing the writer to insert, delete and move text--should also ease the revision process for students. If coupled with revision instruction that is particularly appropriate for LD students, the computer might facilitate content revision for this population. Responding to LD students' particular difficulty focusing on more than one aspect of their writing at one time, Oremus (1987) uses "targeted, incremental revision"--focusing on one specific aspect of the writing at a time--to guide them in reviewing and revising their writing. If coupled with the computer's revision features, a targeted, incremental approach to revision might facilitate a level of revision focused on changing meaning, which is not generally associated with LD students' writing.

In terms of social context theories, the "interactive" features of the computer may facilitate the kinds of teacher/student and peer collaboration and response that contribute to writing development. The interactive features of the computer are the upright visible monitor, which displays the writer's text to someone standing three feet away, combined with the printed text. The big writing surface and the readable print make it easier for students to interact with their own text--rereading and reviewing what they have written as a stimulus to more writing. The teacher should be able to monitor students' writing more easily and prompt the student who has run out of ideas. The visibility of the students' writing might encourage students to respond spontaneously to one another's texts during writing and thus stimulate elaboration or revision. Clearly readable printouts should facilitate peer conferencing, provided students are taught effective ways to respond to each other's texts. In facilitating both teacher and peer response to writing, the computer may encourage students to use and eventually internalize strategies for elaborating, reviewing, and revising their writing. The interactive features of the computer may be particularly valuable

to the LD student if they facilitate rereading and self-monitoring and if they enable the teacher to intervene earlier in the LD student's writing process.

All of these benefits may contribute to the improvement of LD students' attitudes toward their writing and toward themselves as writers. For example, in transforming illegible handwriting to readable print, the computer may alleviate students' negative feelings associated with producing work that "looks bad." The professional look of the text, separate from the content, as well as the increased ease of writing, may motivate the student to write more and improve his/her self-image as a writer.

It is possible that computers will impede LD students' writing process. Managing computer and printer equipment and learning software may add additional burdens for students who are already struggling with the multiple task demands of writing. Although the teacher can more easily observe the students' actual writing process, the teacher may find during writing sessions that he/she is responding to the part of the text that is visible on the monitor, rather than the whole text. Students with substantial motor coordination problems may have difficulty managing keyboarding and taking advantage of the computer's revision features. And the possibility of deleting may stimulate particularly anxious, low-confidence students to erase what they write. Finally, the ease of revision might encourage more minor revisions during composing, which could reduce fluency (Bridwell, Nancarrow & Ross, 1984; Gould, 1981). This may be particularly likely where students are not receiving specific instruction in how to respond to their own and others' writing.

Research Support for Computer Benefits

Few studies have addressed the question of whether students write more on the computer than by hand. Though Kane (1983), in an

exploratory study, found that students wrote more with a computer than with paper and pencil, others found that handwritten and wordprocessed texts did not differ in length when the writing took place over a short period of time (Murry & Goldman, 1986; MacArthur, Graham, & Skarvold, 1987). The impact of word processing on students' attitudes toward writing is a critical area of study for learning disabled students; the very few researchers who have addressed this area (Kurth, 1987; MacArthur, Graham, & Skarvold, 1986; Vacc, 1987) report that learning disabled students were more positive about writing when they were composing on the computer.

Research on computers and writing has focused mainly on the impact of the computer on the amount and kind of revision students carry out and whether those changes in revision affect the quality of the writing. Some studies have found that students revise more when on the computer (Collier, 1983; Bridwell, Sirc & Brooke, 1985; Daiute, 1984); other studies have found that students revise less (Harris, 1985; Hawisher, 1987; Daiute, 1986). All of these studies were carried out over a relatively short period of time and with a single writing/revision task, and none with special needs students. None of them provided students with instruction in or a focus for their revision. Arguing that it is knowledge of revision strategies, not the writing tool per se, that promotes effective revision, Graham and MacArthur (1987) taught three fifth- and sixth-grade LD students a revision strategy and had them apply it in rewriting an essay on the computer. The strategy resulted in increased meaning-changing revisions and an increase in the quality of the writing product. Since all of the students' work in this study was carried out on the computer, and there was no paper-and-pencil control group, we don't know whether the computer enhanced the students' ability to carry out the revision strategy.

While the special features of word processors on their own--electronic typing, the "interactive" monitor and the simple availability of insert, delete, move and erase features--are promising for LD students, they are most likely to make a difference to LD students' writing when coupled with good writing instruction. Until the present study, no research has looked systematically, over an extended period of time, at the impact computers might have on LD students' writing process and written products in a context in which they are receiving sustained writing process instruction.

PURPOSE OF THE STUDY

The purpose of the present study was to integrate computers fully as a writing tool into mainstream classrooms that contained excellent writing process instruction, and to see whether the presence of the computers enhanced the way the teachers interacted with their LD writers and the students' writing process and products. The study is the second and final phase of a four-year investigation of the role of word processing in writing instruction with LD students.

In the first phase (1984-86), project staff identified several key features of effective computer-supported writing instruction based on observations carried out in resource rooms. Over the two years, nine resource room teachers, 36 LD students and several classroom aides and LD specialists were the focus of weekly observation, ongoing interviewing, collection of student writing products, and periodic review meetings. Figure 5 lists products--technical reports and articles--from Phase 1.

In the second phase (1986-88), the project adapted and refined that model in the mainstream classroom settings. The purpose of this second phase of the project was to identify the optimal conditions for using computers in writing, implement them in

Figure 5

Products of Phase I

Morocco, C.C. 1987. *Teachers, children and the magical writing machine: Instructional contexts for using word processing with learning disabled children.* Final report, EDC Writing Project, 1984-86. Newton, Mass.: Education Development Center, Inc.

Morocco, C.C., and Neuman, S.B. 1985. *Teaching children to write with computers: Comparing approaches.* Technical report no. 1, EDC Writing Project, October. Newton, Mass.: Education Development Center, Inc.

Morocco, C.C., and Neuman, S.B. 1988. Word processing with learning disabled children. In *Word processing in the early grades.* New York: Teachers College Press.

Morocco, C.C., and Neuman, S.B. 1986. Word processors and the acquisition of writing strategies. *Journal of Learning Disabilities* 19, no. 4 (April): 243-47.

Morocco, C.C.; Neuman, S.B.; Cushman, H.; Packard, D.; and Neale, A. 1985. *"I know what to say!" Writing activities for the magical machine.* Curriculum resources, EDC Writing Project, October. Newton, Mass.: Education Development Center, Inc.

Neuman, S.B., and Morocco, C.C. 1987. "Two hands is hard for me": Keyboarding and learning disabled children. *Educational Technology* (December), 36-38.

Neuman, S.B., and Morocco, C.C. 1987-88. Writing with word processors for remedial students. *The Computing Teacher* (December/January), 45-61.

Neuman, S.B.; Morocco, C.C.; Bullock, M.; Cushman, H.; Neale, A.; Packard, D.; and Traversi, D. 1985. *A model teaching environment for using word processors with LD children.* Technical report no.2, EDC Writing Project, October. Newton, Mass.: Education Development Center, Inc.

several classrooms, and look at the impact on teaching and learning. We took several steps to optimize the learning environments in these classrooms. On the assumption that effective implementation of computer-supported writing for LD students requires several kinds of expertise--about writing, computers and LD students--we selected teams of classroom teachers and remedial teachers and provided them with training and technical assistance in integrating computers into their writing programs. In one school, the team included a school-based computer specialist who was able to assist teachers. In addition, we secured a donation of Apple computers and printers in order to provide every student in the study access to a computer for a minimum of three class periods per week. While all four classrooms had integrated the computer into active writing process programs by the second year, the classrooms nevertheless varied in their level of implementation of a computer-supported approach. These differences are discussed in the Treatment section.

The focus of the first year of Phase 2 (1986-87) was on a series of implementation questions. <u>What machine skills do students need for writing extensively on the computer? What kind of instruction do they need in order to acquire them?</u> In the resource room, students were able to learn keyboard (typing) skills and word processing functions gradually, in the course of writing on the computer. The low ratio of teachers to students enabled teachers to handle whatever skills students had not yet acquired. We learned during the first year in the mainstream classroom (1986-87), however, that unless students become independent in word processing skills before they begin composing on the computer, instruction will continue to focus more on machine problems than writing skills (Dalton, Morocco & Neale, 1987). Because no adequate programs existed, EDC staff, in collaboration with project teachers and a computer specialist from one of the research sites, developed a machine skills

curriculum that all teachers implemented during the final project year (Morocco, Dalton, Morse, Troen & Boles, 1988).

What classroom management problems do teachers need to solve in order to integrate computers into sound writing instruction? What are effective ways of solving them? Through intensive observation, the project identified alternative ways teachers in the research classrooms organized students' time on and off the computer, how they managed different computer configurations (computers in a lab; computers in the classroom; a combination) and how they integrated the computer while teaching students to write such genre as personal narrative, autobiography, fables, fairy tales and realistic fiction.

What kind of collaboration between remedial and classroom teachers and computer specialists supports LD students' writing with computers? The project identified several different models for classroom teacher-remedial teacher collaboration. One was a "pull-out" model, in which LD students left the room for skills work during writing instruction, and an alternative model was one in which the specialist was a full member of the teaching team and provided services unobtrusively within the classroom.

The major question for the second year of Phase 2 (1987-88) and the focus of this report, was what is the impact of a well-implemented, computer-supported writing program on LD students' writing and teachers' instructional approach. More specifically the questions addressed included:

- Do fourth-grade students in computer-supported versus paper-and-pencil writing process programs differ in relation to narrative writing quality, self-perception and attitudes towards writing?
- Do LD versus non-LD students in the two different kinds of programs differ in relation to narrative writing quality, self-perception and attitudes toward writing?

- Do LD students in the two different kinds of programs differ with regard to those same outcomes?

In a treatment and a comparison classroom in each site, the project gathered repeated writing samples and attitude measures, and applied both traditional and newer methods of growth analysis to determine students' progress in both settings. The analysis focused on the impact of the program on the class as a whole, including both normally achieving and LD students, and on LD students alone. The underlying assumption was that classroom teachers are unlikely to adopt innovations for LD students in their classrooms that don't also benefit their entire classroom. The hypotheses were that the quality of students' writing in the treatment classes would increase more than that of students in the comparison classes, and that LD students' rate of growth in writing would at least equal that of normally achieving students. The latter is an important hypothesis, since LD students' rate of achievement has been found in other research to diverge from that of normally achieving students at about the fourth grade (Moran, 1981; Meltzer et al., in press; Poplin, 1983; Wiig & Semel, 1976). Another hypothesis was that students in the computer-supported classroom would enjoy writing more than students in the comparison classroom in each site and would perceive themselves to be better writers.

Although the project considers students' attitudes toward writing to be a critical area of study, our student attitude data,

consistency of pre- and post-assessment of students' enjoyment of and perception of themselves as writers, is not as extensive as our repeated measures of writing quality.

The study also focused on how teachers varied their program to meet individual LD student needs. To answer the question, How do teachers adapt their writing instruction for LD students? the project observed four LD students intensively over a five-month period in each classroom, gathered writing products from each writing session, and conducted interviews with teachers about their students' progress. In addition, teachers were interviewed to gather their perceptions of the changes that had taken place in their approach to teaching writing and their ways of working with LD students over the two years that they had implemented a computer-supported program.

The data gathered will enable us to continue beyond the official ending of the project with analyses that go beyond the original goals of the research. For example, writing samples from all composing/revising sessions of the 16 LD students and a sample of normally achieving students in each treatment classroom will enable us to look at composing and revising patterns. We will explore the question: How do LD and normally achieving students compare in the kinds of revisions they make when composing and revising on the computer? We will replicate the analysis within

writing activities representing three different genres: fables, fairy tales and autobiography.

THE SCOPE OF THIS REPORT

This final report will focus on the major impact question for Phase 2--whether the computer in combination with excellent writing process instruction can have a positive impact on the quality of students' writing, and students' attitudes towards writing and themselves as writers. After describing the methodology, the report describes the major elements of the computer-supported writing program and then describes the variations in the ways teachers in the four classrooms implemented those elements. A presentation of the results is followed by a discussion of the major findings.

II: METHODS

OVERVIEW

The EDC Writing Project investigated the impact of computers on LD and non-LD fourth-grade students in three diverse greater-Boston area school districts over the course of two years. In Year 1, 15 LD and 74 non-LD students in four classrooms participated in the study, writing on computers two to three times per week from October through June. The teachers focused on developing procedures for setting up and managing a computer-supported writing program. In Year 2, the study expanded to include a comparison class in each district (see Table 1). Thirteen LD and 53 non-LD students in the three comparison classes wrote with pencil and paper throughout the school year. In the four treatment classes, 16 LD and 56 non-LD students wrote on the computer three and sometimes four times per week. During this second year, the treatment teachers focused on developing strategies to help individual LD students and increased their use of the computer to support specific writing goals, such as using the Block Move function to help students improve the organization of their texts.

Although we conducted an intensive observational study of the treatment classes in Years 1 and 2, this report presents the results of our Year 2 comparative study of the computer-supported versus pencil-and-paper writing programs in the treatment and comparison classes. A major focus of our data gathering was assessing the quality of students' writing at four points during the year. In addition, we obtained pre-post measures of students' self-perceptions and attitudes toward writing in the treatment and comparison classes. This report presents the results of our statistical analysis of these comparative assessments; other forthcoming reports will present analyses of

Table 1

Year 2 Research Sites

District	School	Class	Students	Non-LD	LD
Brown	1	Treatment	21	16	5
	1	Comparison	22	17	5
Carver	1	Treatment	21	17	4
	2	Comparison	22	18	4
Waverly	1	Treatment	15	11	4
	1	Treatment	15	12	3
	2	Comparison	22	18	4

observational data, case study information, students' written texts, teacher assessments of students, and teacher interviews.

SITE SELECTION/SAMPLING

The Districts

Located within the greater-Boston area, the three research districts are different demographically (see Table 2). The Brown District is an ethnically diverse small city, with a substantial number of families for whom English is a second language. Two career families are common, and family incomes range from low-average to high. The public school system enjoys a reputation for excellence, encouraging educational innovation in its schools and providing its teachers with opportunities for training and professional development. The Carver District is an affluent, mostly white suburb in a country setting that includes farms and orchards. Like Brown, this school system demonstrates above average academic achievement, is supportive of educational innovation, and offers teachers substantial training and support. Waverly is an ethnically diverse small city of low to middle income families, including an extensive community of Eastern European and Middle Eastern families. The school system, while supportive of educational innovation, has fewer resources available to teachers for training and professional development.

The Teachers

Participating classroom and specialist teachers were recommended by their school principals and, in some cases, their district language arts supervisors for participation in the study.

Table 2

Demographic and Socio-Economic Characteristics of the 3 Districts*

City/Town	Brown	Carver	Waverly
Population			
Mass. census, 1985	58,152	15,636	32,189
Persons per square mile	8,073	637	8,245
Race and Spanish Origin			
White	92	97	98
Black	2	1	0
Asian/Pacific Islands	3	1	1
Other	1	0	0
Spanish origin	2	1	2
Educational Attainment			
College graduate and beyond	34	32	17
Income			
Per capita income, 1983	16,527	18,450	11,928
Median family income, 1979	25,389	34,353	22,097
Civilian Labor Force			
Managers and professionals	50	47	30
School System, 1984-85			
Pupils per teacher	14	16	14
Average teacher salary	26,525	36,258	28,630
Per student expenditure	3,903	4,010	3,481
% high school graduates going on to 4-year colleges	72	N/A	56

*1980 U.S. Census, except as noted.
Source: Massachusetts Municipal Profiles, Information Publications, Wellesley Hills, MA

Treatment Teachers

In Year 1, we selected four treatment classroom teachers who:

- had access to computers for all students two to three writing periods per week.
- had at least four moderately LD students (defined below) mainstreamed in the classroom.
- had at least three years of experience with a writing process approach to teaching writing at the fourth-grade level (as described in the Introduction).
- were identified as excellent teachers by their peers and administrators.
- indicated strong interest in integrating the computer into a writing process program.
- had at least one year of experience using computers.

By the beginning of the Year 2 study, all of the treatment teachers had one year of experience teaching writing on the computers, increased computer availability so that all students had access to the computer for three writing periods per week, and support from a special needs or remedial room teacher. In addition, each of the school research teams included a remedial or special needs teacher, and in Brown, a computer specialist. These specialists worked cooperatively with the classroom teacher, sometimes working within the classroom/writing lab with individual students (Brown and Carver), and sometimes supplementing the teacher's program in the resource room (Waverly). Table 3 presents a summary of the treatment classes' resources.

Comparison Teachers

We were able to select another fourth-grade teacher as the comparison teacher from within the same school in the Brown District, but this was not possible in Carver and Waverly. In Carver, the other fourth-grade teacher in this school used

Table 3

Year 2 Treatment Classes Resources

District/School		Computer Resources			Personnel Resources
		Student: Computer Ratio		Software	Specialist
		Class	Lab		
Brown	1	16:1	1:1	*Bank Street Writer* (Broderbund, 1984)	• Computer specialist 3 times per week in writing class • Remedial teacher 2 times per week in writing class
Carver	1	3.5:1	1.4:1	*Bank Street Writer III* (Scholastic, 1986) *Magic Slate* (Sunburst, 1984)	• Resource room teacher 2 times per week in writing class
Waverly	1	15:1	1:1	*Bank Street Writer III* (Scholastic, 1986)	• Resource room teacher writing with LD students in resource room 2-5 times per week

computers extensively in his classroom, and in Waverly, both of the fourth-grade teachers in the school were already participating in the study. Therefore, we consulted administrators and language arts specialists in each district who were familiar with their school/teacher characteristics, asking them to recommend a comparison teacher from another school in the district that they viewed as comparable to the treatment teacher's school in relation to student achievement levels and demographic and SES characteristics. The comparison teachers met the following criteria:

- were not using computers to teach writing
- had at least four moderately LD students mainstreamed in the classroom
- had at least three years of experience with a writing process approach at the fourth-grade level
- were identified as excellent teachers by their peers and administrators

While we used these criteria to select teachers for the study, we recognized there would probably be important variations in how each teacher implemented a writing process program. Our weekly treatment classroom observations allowed us to collect a detailed record of the treatment teachers' program implementation. Chapter III presents detailed description of each treatment class's instructional context. To assess the writing program in each of the comparison classes, we interviewed the teachers prior to the onset of the study and asked them to describe their writing goals and lesson plans for the year. We also asked them to keep samples of three students' writing for each of their writing assignments, which we reviewed in January and at the end of the year to assess the types of writing assignments and students' general level of performance.

The comparison teacher in Brown gave his students many writing opportunities in a variety of genres (poetry, description, personal narrative, letters, journals) and encouraged them to pre-write, compose, revise and edit their work. Students wrote daily in a journal, in addition to their other writing assignments. Teacher conferencing and peer collaboration were an integral part of his program. He supported his writing process program with instruction in basic writing skills, such as punctuation and grammar. The Waverly comparison teacher also gave her students many opportunities to write, and integrated writing process and basic skills instruction. Students wrote many brief pieces, with some revising and conferencing on selected ones. The comparison teacher in Carver differed from the other teachers in the study in that she gave students fewer opportunities to write and restricted the extent to which students collaborated with each other and worked with a piece of writing over time. Typically, students were given a topic each week to write about. They turned in a draft to the teacher, who made editing corrections and occasionally revision suggestions. The students then prepared their final copy. A language arts specialist supplemented the teacher's writing program, working with the students for several lessons on fluency and word choice.

Students

In Brown, the treatment class of 21 students and the comparison class of 22 students each included five LD students. In Carver, the treatment class of 21 students and the comparison class of 22 students each included four LD students. Waverly included two small treatment classes of 15 students each, with three and four LD students in each class, respectively. Since these two teachers planned their writing program together and statistical analyses of results did not yield significant differences between the two classes, for analysis/discussion purposes we combined these classes into a single treatment class of 30 students including

seven LD students. The comparison class in Waverly included 21 students, four of whom were LD students.

It was difficult to obtain comparable achievement test data on the sample students, since the districts used different tests, administered them at different times and, in the case of Waverly, exempted special education students from taking group-administered tests. Table 4 presents a comparison of the treatment and comparison classes' performance on a state competency test administered in the spring of grade three. A score of 70 percent correct represents a passing score on this test of basic competence. Given the low ceiling of the test, there is little differentiation among above-average students, and even average students do quite well. Note that within each district, the treatment and comparison classes demonstrated similar achievement levels, and that all of the classes in the study were above average in achievement.

LD Students

We identified the LD students according to the following criteria:

- ranking in the fourth quartile on a National Assessment of Educational Progress (NAEP) writing assessment conducted by EDC Writing Project Staff in the fall
- evidence of average or above-average IQ (source: student record data on cognitive skills testing)
- evidence of written language achievement patterns that were at least one year below current grade level (source: student record data on language achievement, teacher evaluation of class writing samples)
- evidence of no other major disability such as cerebral palsy, emotional disturbance, auditory or visual impairment, or mild mental retardation (source: student record data)

Table 4

Student Achievement—Percent Correct on Grade 3 State Competency Test

		Reading			Math		
Site	**Class**	**n**	$\overline{X}$	**(SD)**	**n**	$\overline{X}$	**(SD)**
Brown	Treatment	19	92	(7.6)	19	92	(6.8)
	Non-LD	15	94	(5.9)	15	95	(4.3)
	LD	4	85	(9.2)	4	83	(6.8)
	Comparison	18	90	(13.4)	18	89	(15.2)
	Non-LD	14	94	(6.1)	14	96	(3.6)
	LD	4	75	(22.4)	4	67	(20.0)
Carver	Treatment	17	95	(5.0)	17	92	(6.3)
	Non-LD	13	95	(4.7)	13	93	(6.4)
	LD	4	95	(6.4)	4	91	(6.3)
	Comparison	16	96	(4.2)	16	89	(6.5)
	Non-LD	15	96	(4.7)	15	90	(6.5)
	LD	1	100	(0)	1	82	(0)
Waverly	Treatment	27	94	(5.9)	29	91	(8.4)
	Non-LD	22	94	(6.4)	23	93	(8.0)
	LD	5	94	(3.4)	6	86	(8.7)
	Comparison	17	93	(9.2)	18	87	(9.2)
	Non-LD	14	96	(5.9)	15	91	(4.7)
	LD	3	81	(13.7)	3	70	(5.0)

- evidence that teachers and specialists had identified the student as having mild to moderate learning problems [placement in special education was not required since the schools varied widely in their selection and placement policies] (source: student record data, child study team notes, special needs/remedial teacher consultation)

Although this sample of LD students met the general criteria outlined above, there was substantial variation among the LD students in terms of their specific constellation of writing strengths and weaknesses and their general learner characteristics. For example, some students demonstrated major learning difficulties in all academic areas, while others had difficulty primarily in writing; some students struggled to express themselves in a few sentences, while others wrote lengthy texts, but with little focus and numerous mechanics errors. While this analysis summarizes the results for LD students, we caution against generalizing the findings to "the average LD student." There are likely to be important differences in learner outcome, based on individual differences among students.

MATERIALS/EQUIPMENT

Computer Hardware and Software

All of the treatment students wrote on Apple II-e or Apple GS computers. In Brown, students used the Bank Street Writer word processing program (Broderbund, 1984); in Carver, the LD students used the Bank Street Writer III program (Scholastic, 1986) since they had been using it in the resource room the previous year while the non-LD students used Magic Slate (Sunburst, 1984); and in Waverly, students used the Bank Street Writer III word processing program.

Word Processing Curriculum

In Year 2, each of the treatment classes used a word processing curriculum, "Mastering the Writing Machine" (1988), developed collaboratively by the EDC research staff and the Brown classroom teachers and computer specialist during the preceding summer. Designed to be used with either Magic Slate or Bank Street Writer, the program systematically teaches students basic file management and editing functions prior to using the computer for their own extended writing pieces. Once students have mastered basic skills, they are taught advanced skills such as Block Move when they are ready to apply them in service of a particular writing goal (i.e., organization/sequencing).

INSTRUMENTS

NAEP Writing Assessment Materials

The National Assessment of Educational Progress was initiated in 1969 by the United States Congress to measure the academic achievement of American students at the elementary, middle, and high school levels (NAEP, 1986). The NAEP writing assessment materials are developed by a team of writing experts and measurement specialists and are extensively field-tested to ensure their validity and reliability and "to eliminate any potential bias or lack of sensitivity to particular groups" (NAEP, 1986, p. 89).

We recognize that there are advantages and disadvantages associated with using the NAEP Writing Assessment tasks and procedures. The advantage is that the NAEP assessments are standardized measures that are rigorously developed by experts in the field and extensively field-tested. The NAEP writing assessment has been criticized, however, as measuring a type of writing that is at odds with a writing process approach. While

the NAEP requires that students produce a complete text in one sitting, a writing process approach engages students in writing a piece over an extended period of time, and drawing on peer and teacher response to elaborate and revise in successive encounters with the text.

For the purposes of this assessment, we felt the NAEP writing task to be appropriate, since general improvements in writing should transfer to some extent to writing in a more contained context. We will be conducting additional analyses that will assess children's progress in the more naturalistic context of composing, revising, conferencing, editing, and publishing a text in their classrooms.

We selected three of the NAEP narrative writing assessment tasks. Each of the writing prompts is given below.

> Assessment #1: <u>The Flashlight</u>. When you come home from school one day, you find a flashlight on the table. Beside the flashlight is a note addressed to you. The note says: This flashlight has very special and unusual powers. Write a story about your adventures with this special flashlight.
>
> Assessment #2: <u>The Moon</u>. Here is a picture of an astronaut on the moon. Write a story about an adventure that might happen on the moon.
>
> Assessment #3: <u>The Boat</u>. Here is a picture of children playing on an overturned boat. Write a story about an adventure the children might have on their day at the beach.

In addition, for the post-assessment we designed a fourth task that was very similar to Task 1, but we substituted a key that unlocks something "very special and unusual" for a flashlight "with special powers." The four writing tasks are presented in Appendix A.

Assessment #4: The Key. When you come home from school one day, you find a key on the table. Beside the key is a note addressed to you. The note says: This key unlocks something very special and unusual. Write a story about your adventures with this special key.

Self-Perception Profile for Children (Harter, 1985)

We used the Self-Perception Profile for Children to measure pre-post changes in students' self-perceptions. The scale is designed to tap children's perceptions of themselves in five specific domains (scholastic competence, social acceptance, athletic competence, physical appearance and behavioral conduct). It also measures children's sense of their global self-worth. Students are presented a series of statements, such as, "Some kids often forget what they learn BUT other kids can remember things easily," and are asked to decide first which kind of kid is "most like him" and then whether this is "really true for me" or "sort of true for me." The instrument demonstrates acceptable reliability and validity, but it should be noted that the scale was developed from four samples drawn from lower middle class to upper middle class communities in Colorado and that 90% of the subjects were Caucasian. Harter cautions against use of this measure with special populations, reporting that LD students yield a different factor pattern and subscale interpretation. We used the same measure for all students, since we felt it important to administer the instrument in a whole class setting that did not single out LD students. However, the results for LD students should be interpreted with caution.

Student Writing Questionnaire

The Student Writing Questionnaire was developed by the EDC research staff to assess children's perceptions about themselves as writers. The instrument was piloted in the fall of Year 2 with one fourth-grade class. Based on their responses, we revised the questionnaire, simplifying it and deleting some questions. The post-test questionnaire repeated the questions asked in the pre-test questionnaire and added a few questions about students' evaluations of their class writing program. Additional questions for the treatment students focused on whether they thought the computer was helpful to them in the various phases of the writing process (finding an idea, composing, revising, editing, etc.). The pre- and post-test questionnaires are presented in Appendix B.

DATA COLLECTION PROCEDURES

The classes participated in the study from September to May. Treatment class students carried out their writing with paper and pencil from September through November while they acquired basic keyboarding and word processing skills, using the EDC word processing curriculum. By the beginning of December, students had generally mastered the basic file management and editing functions of the word processor, and so teachers began integrating the computer into their writing programs in December. During the period of January-May, students wrote on the computer three times

per week for approximately 30-40 minutes each. In addition to these scheduled periods, students were also able to use a computer in their classroom during free time, and occasionally before or after school. Students saved each draft of their writing under a separate file name on their individual data disks and were encouraged to print out a draft once a week. They used their printouts to conference with peers and the teacher and to read aloud during group sharing times. Each student maintained a writing folder that included his/her pre-writing, revised and edited drafts, and notes from peer and teacher conferences.

From November through May, each treatment writing class was observed at least once and sometimes twice a week by one of the research assistants. Primary responsibility for a class was assigned to a specific researcher to encourage a collaborative relationship with the teachers and to contribute to the researcher's understanding of the instructional context and LD students' progress over time.

The research assistants followed a systematic observation procedure, taking field notes focused on selected LD students, but including the teacher's opening and closing of the writing class and intermittent interactions with both non-LD and LD students. The researchers were trained in the observation procedure during two class writing sessions. The principal investigator and the research assistant observed simultaneously for three minutes and

then stopped, compared notes and resolved differences. They continued this cycle until there was a comparable level of detail and content in the two sets of notes. Field notes were also reviewed at weekly staff meetings to ensure a continued level of reporting comparability. A description of the observation procedure is presented in Appendix C.

In addition to recording weekly observation notes, the research assistant also printed out copies of the LD students' drafts each week and collected writing folder information (conference sheets, notes, etc.) periodically. LD student individual data disks were periodically collected and copies of all drafts printed out.

The teachers in the comparison classes carried out their writing program as they normally would during the school year. They saved student writing samples for three students, including pre-writing, revisions and final drafts, for each major writing assignment. The research staff collected these samples in January and again in May.

The Assessments

NAEP Writing Assessment

In October, January, March and May, the research assistants administered a NAEP writing assessment task in each of the seven

classrooms. We revised the NAEP administration procedure to include a brief brainstorming session for students to share their ideas before beginning to write. The researcher read the writing prompt aloud to the class, the class brainstormed together for approximately ten minutes while the researcher recorded their ideas on the chalkboard, and then the students wrote their stories with pen and paper during the remaining 40-45 minutes. Students were reminded to reread their stories before turning them in and to make any necessary changes or corrections. After the stories were collected and copied, copies were returned to the students. It should be noted that some children in the Brown and Carver treatment classes, and the Brown comparison class, where students typically spent many days writing a single piece, reported that this type of writing assignment was different from what they were used to, and that they found it difficult to write a complete piece in one sitting.

Holistic scoring is a widely used method to evaluate students' writing samples. In holistic scoring, the rater reads the piece quickly and judges the overall quality of writing in relation to the range of performance represented in the total set of writing samples (Cooper & Odell, 1977). Primary trait scoring focuses on a specific aspect of writing, such as communicative effectiveness or mechanics. We used the NAEP primary trait scoring guide for imaginative narrative to rate students' writing. We felt this method would capture students' narrative writing skill, without

penalizing LD students for mechanics errors. The primary trait is "Invention of a narrative based on a given situation," and levels of performance range from one (no evidence of story telling, i.e., an accumulation of details without a situation) to four (fully controlled storytelling, i.e., a complete story with appropriate detail and resolution). The NAEP scoring guide is presented in Appendix D.

The 554 writing samples were rated by 16 teachers in two scoring sessions. All of the scorers had experience teaching writing at the elementary or secondary levels, and none of the teachers were familiar with either the students or schools participating in the study. Prior to the scoring, the principal investigator and a research assistant read a random selection of writing samples and selected ten samples that represented a full range of student performance to use as rater training materials. All identifying information was removed from the texts, identification numbers were assigned, and stories were randomly sorted into rater packs of 15 stories each. Each scoring session began with a rater training session. The primary trait scoring guide was explained, and the four writing prompts were presented and discussed. Raters read through the training pack of ten stories to get a sense of the range in student performance and then rated the first story from one to four. Scores were discussed to clarify the levels in the scoring guide and to resolve discrepancies between raters. Raters continued to score the stories in the training pack,

stopping and discussing individual ratings after each story. In this way, the raters calibrated their ratings.

Following the training, raters were randomly assigned a scoring pack. They read and rated the stories at their own pace, recording their score on a scoring sheet. When they finished the pack, they returned it to the researcher and were given another pack. Raters read between two and three packs during each scoring session. Each pack was scored by two raters, and stories receiving ratings that differed by more than one point were rated by a third rater. The raters were within one point of agreement on 96.9% of the writing samples, with only 17 of the 554 writing samples requiring a third rating. The two ratings were summed for the analyses, so a story rated '4' by one rater and '3' by the second rater received a combined score of '7'.

The Self-Perception Profile for Children (Harter, 1985)

This survey was administered by the two research assistants in November and May to the treatment and comparison classes in Carver and Waverly. We followed the administration procedures outlined in the test manual, introducing students to the notion of a rating survey that has no "right" or "wrong" answers, demonstrating how to respond using two sample items, and then reading each item aloud to the class as students filled in their answer sheets with pencil. We did not administer the Harter Scale in the Brown

District because the teachers felt that some of the questions were invasive of children's privacy. While the students in the other districts seemed to either enjoy, or at least not mind, responding to the items during the pre-post administrations, we discussed the survey with them after the final assessment and found that they were generally uncomfortable with questions that focused on their physical appearance and would have preferred not to answer those questions. The group administration and reading aloud of each item, though a recommended procedure, may have heightened students' sensitivity to these types of questions. Students' protocols were scored in accordance with the manual scoring procedure by an administrative assistant and verified by a research assistant.

Student Writing Questionnaire

The Student Writing Questionnaire was administered by the research assistants in all seven classes during October and May. We told students we were interested in finding out what they liked/didn't like about writing and what they perceived to be the "easy" and "hard" parts of writing. Each question was read aloud as students wrote their response on the questionnaire form. During the post-assessment in May, we added additional questions to find out which writing assignments students had enjoyed and to obtain the treatment students' assessment of whether they found the computer

helpful to their writing. The student responses were coded by the administrative assistant and verified by a research assistant.

DATA ANALYSIS: GROWTH MODELING

The study used growth modeling, in addition to traditional gains-score and repeated measures analysis, to assess change in students' writing quality over the four NAEP assessments (for a detailed discussion of the growth-modeling approach used in this analysis, see Willett, 1988). Traditional approaches to the assessment of change in students' writing have primarily relied on comparisons between students' pre- and post-test performance, using either the simple difference between the pre- and post-test scores, or post-test scores adjusted by the pre-test scores as a covariate in the statistical analysis. A number of researchers, however, have pointed out that two time points generally are not sufficient for studying change (Bryk & Weisberg, 1977; Rogaso, Brand & Zimowski, 1982; Willett, 1988). Even when the measurement instruments appear to be highly reliable or stable across two time points, the reliabilities of the individual change scores are often very low (Linn & Slinde, 1977; Bryk & Raudenbush, 1987). This problem may be exacerbated in studying children's writing, where raters' subjective judgments of writing quality and young students' substantial within-individual variability in writing performance both contribute to the amount of measurement error (Swartz, 1986).

The benefits of using a growth-modeling approach are several. Willett (1988) shows that it is possible to increase growth rate reliability by one or two hundred percent by adding an extra assessment period to the traditional pre-test/post-test design. In addition, by using information about individual variability that is available from assessments collected over several time points, it is possible to compensate for the influence of measurement error and increase the power of statistical tests. Further, with more than two data points available for each student, it is possible to test for non-linear trends in the growth curves.

As Willett (1988) discusses more fully, a growth-modeling approach gives a more comprehensive view of the individual learning process, allowing us to ask such questions as:

> What is the nature of individual growth? By having several data points rather than just two, we are able to distinguish between situations where the rate of progress may be fairly steady over the entire period (linear growth) and situations where progress may slow down or even level off after an initial spurt (curvilinear growth). The potential implications for instruction may be important. Certain instructional interventions may result in consistent linear growth over the course of a school year, while other strategies may show short-term effects that eventually level off.
>
> What is the starting point for growth? Students may show different starting points, and their subsequent rates of progress may be related to where they start. Students who begin at higher levels may continue to make relatively high rates of progress, or it may be that growth is the greatest for those students who start off at lower levels.

What is the average level of performance? Students' growth rates may or may not be related to their average level of performance. For example, two groups may achieve comparable growth rates, but differ in relation to their average level of performance if they began at different points.

What is the rate of growth? By assessing the rates of growth for individuals, we are able to identify students who are changing most rapidly and most slowly. If we determine that the nature of individual growth is largely linear in form, we can compare the relative rates of growth of different individuals or groups of individuals and test the outcome of a particular intervention. If we find that growth is not strictly linear, but that there are certain periods of high growth followed by some leveling off period, we can compare the relative rates of progress within specific growth periods.

What is the variability of individual performance? Children may show similar levels and rates of growth overall but may still vary in how consistently or steadily they change. Some children may show steady growth and predictable improvements from one time to the next, while other students may show dramatic wobbles in their growth trajectories. There may be major dips and unexpected rises in the performances of individual children over time, and some of these may be important indicators of learning.

In this study the growth analysis took place in two phases, as recommended by Willett (1988). In the first within-subject phase we used standard regression procedures to regress each student's NAEP writing quality scores against time. For each student we used the scores from the four writing assessments to obtain estimates of the standard regression parameters: the intercept value in the regression equation using centered data represents the student's average level of performance; the slope of the line represents the student's rate of growth; and the standard error of the slope represents the student's variability in performance.

These individual estimates were then used as the dependent variable in the second between-subjects phase of the OLS regression analysis, which compared group growth rates, levels of performance and variability. We also used information about students' variability obtained in the first phase of the analysis to reduce measurement error in a weighted least-squares regression analysis in the second phase, but the results were comparable to those obtained in the unweighted analysis and are therefore not reported.

Because we had four writing samples, we were able to inspect for possible quadratic or even cubic trends across the period of the study. However, our preliminary examination of the growth trajectories for each student led us to choose a linear growth model. While some of the students showed dips and peaks in their scores, our overall impression of their progress--as well as our assumption that the effects of the computer-assisted writing curriculum would be gradual and cumulative in nature--led us to choose a linear growth model as the most effective summary of the impact of the treatment.

The following analyses were carried out, using three main dependent variables:

Mean levels of performance on the NAEP. This analysis compared average writing quality scores (average of the slopes), which were

derived from the estimates of mid-year performance obtained from the Phase 1 regression estimates of growth for each student.

Mean rates of growth. This is the main focus of our analysis, comparing students' rates of progress (mean slope) across different classrooms or types of students.

Variability in growth. For these analyses we looked at the inconsistencies or deviations in each student's performance from the overall regression estimate of the individual's linear growth rate. For some students, the pattern of writing quality performance was quite regular and fit the regression growth estimate closely. For other students, observed scores varied substantially from the estimated regression line. We used the standard error of the growth-rate estimates to help us determine whether there were any systematic differences across classrooms or between LD and non-LD students in the predictability or variability in performances.

Harter Self-Perception Profile Analysis

Students' pre-post difference scores were analyzed, using a 2 (treatment vs. comparison) X 2 (LD vs. non-LD) Analysis of Variance statistical design.

Student Writing Questionnaire

Three questions that we thought were of particular relevance to the study were selected from the writing questionnaire for analysis: How much do you enjoy writing (not at all, some, a lot)? How good are you at writing? (not very good, good, very good)? and How much writing do you do (a little, some, a lot)? The difference scores between students' pre- and post-test questionnaires were computed to identify students whose perceptions about themselves had changed. In addition, we analyzed treatment class students' perceptions of whether the computer was helpful to them at various stages of the writing process. Since many students did not change their perceptions over the course of the study, the small number that did made it difficult to rely on changes in percentages as reliable indicators of major trends. Therefore, we are presenting the results using descriptive statistics rather than tests of statistically significant differences. The caveat, of course, is that these results should be viewed as preliminary and only suggestive of directions for further inquiry.

Using the statistical techniques outlined above for the analysis of the writing quality data, the self-concept data, and the writing questionnaire, we addressed three main questions:

- Is there a significant difference between the treatment and comparison classrooms?

- **Is there a significant difference between the LD and non-LD students?**

- **Is there a significant difference between the LD students in the treatment classrooms and the LD students in the comparison classrooms?**

III: TREATMENT

ELEMENTS OF A COMPUTER-SUPPORTED WRITING PROGRAM

Drawing on the results of the EDC Writing Project resource room study, the project identified and refined five critical components of a "computer-supported writing program" most likely to benefit both normally achieving and learning disabled students. These include:

- an approach to writing instruction that reflects basic principles of a writing process approach (see Introduction)
- regular access to the computer for writing
- full integration of the computer into varied writing activities
- strong knowledge of machine skills, by both teachers and students
- availability of individualized help for special needs students within the mainstream writing program.

The project made every effort to maximize these components in the treatment classrooms. We selected teachers into the current study whose instruction included as many of these components as possible. In addition, we intervened in the classrooms in a number of ways during the first year to enhance these components and thus optimize the conditions for assessing the impact of a well-implemented computer-supported program in the second year. This section describes the efforts the project made to enhance these five elements in the research classrooms in the first year of the classroom study, then describes the variations across the three sites in their implementation of the elements during the second year of the study.

Process Writing Instruction

Teacher expertise in writing process instruction was our first criterion for selecting project teachers. Because of the difficulty of finding teachers who met all of our criteria (expertise in writing instruction, experience using word processing in writing instruction, possession of mainstreamed LD students, sufficient access to computers), our final selection included experienced teachers who varied to some extent in their approach to teaching writing. To enhance teachers' ability to apply a writing process approach, we set up meetings in the first year (1986-87) in which teachers shared effective teaching strategies (e.g., peer conferencing), and we encouraged teachers to visit one another's classrooms.

Regular Access to the Computer for Writing

Although computer availability varied somewhat in Year 1, in the second year, all students across the four classrooms had access to a computer three class periods per week and sufficient access to printers to print out their work each day. All of the teachers had computers in their classrooms that they could use for group lessons, on-line conferencing, or individual writing or machine skills practice.

Strong Knowledge of Machine Skills

The presence of one person with excellent knowledge of the word processing program being used by students and a good general knowledge of computers was deemed a critical element of computer-supported writing. By the second year teachers in all sites either had sufficient machine skills themselves or (in Brown) a computer specialist available during all writing periods to allow them to manage machine demands smoothly.

Analysis of teacher interactions with students across all three sites during the first year of the classroom study demonstrated that without systematic training in keyboarding and word processing functions, students (LD and normally achieving) continued to be preoccupied with machine "troubles" throughout the year--at the expense of their writing (Dalton, Morocco & Neale, 1987). In the summer after the first year, a computer specialist from Brown, with the assistance of EDC staff and other Brown teachers, developed a "machine skills" curriculum that all teachers implemented between September and November of the second classroom year (Morocco, Neuman, Cushman, Packard & Neale, 1987). The curriculum was designed on the assumption that regardless of the age at which they begin word processing, students need to invest an intensive period of time learning machine skills in order to be able to use the computer as a fluent writing tool. The curriculum requires that students have three weeks of intensive keyboarding training, followed by six to eight weeks of training in basic word processing functions. During this period, the students carry out their writing program with paper and pencil; once they master ten basic machine functions (the curriculum includes a mastery test), they shift their writing to the machine. More advanced word processing functions (Block Move; Find and Replace) are to be taught as appropriate, in the context of students' ongoing writing. Figures 6 and 7 provide an overview of the program and a listing of the machine skills addressed in the curriculum.

Full Integration of the Computer into Writing Activities

Since none of the teachers in the sample had previously used computers consistently in writing instruction, during the first year they explored ways of integrating the computer into various kinds of writing activities. The project provided teachers with a book of computer-based activities based on successful ones from the previous two-year resource room study (Morocco, Neuman,

Figure 6

Machine Skills and Your Writing Program

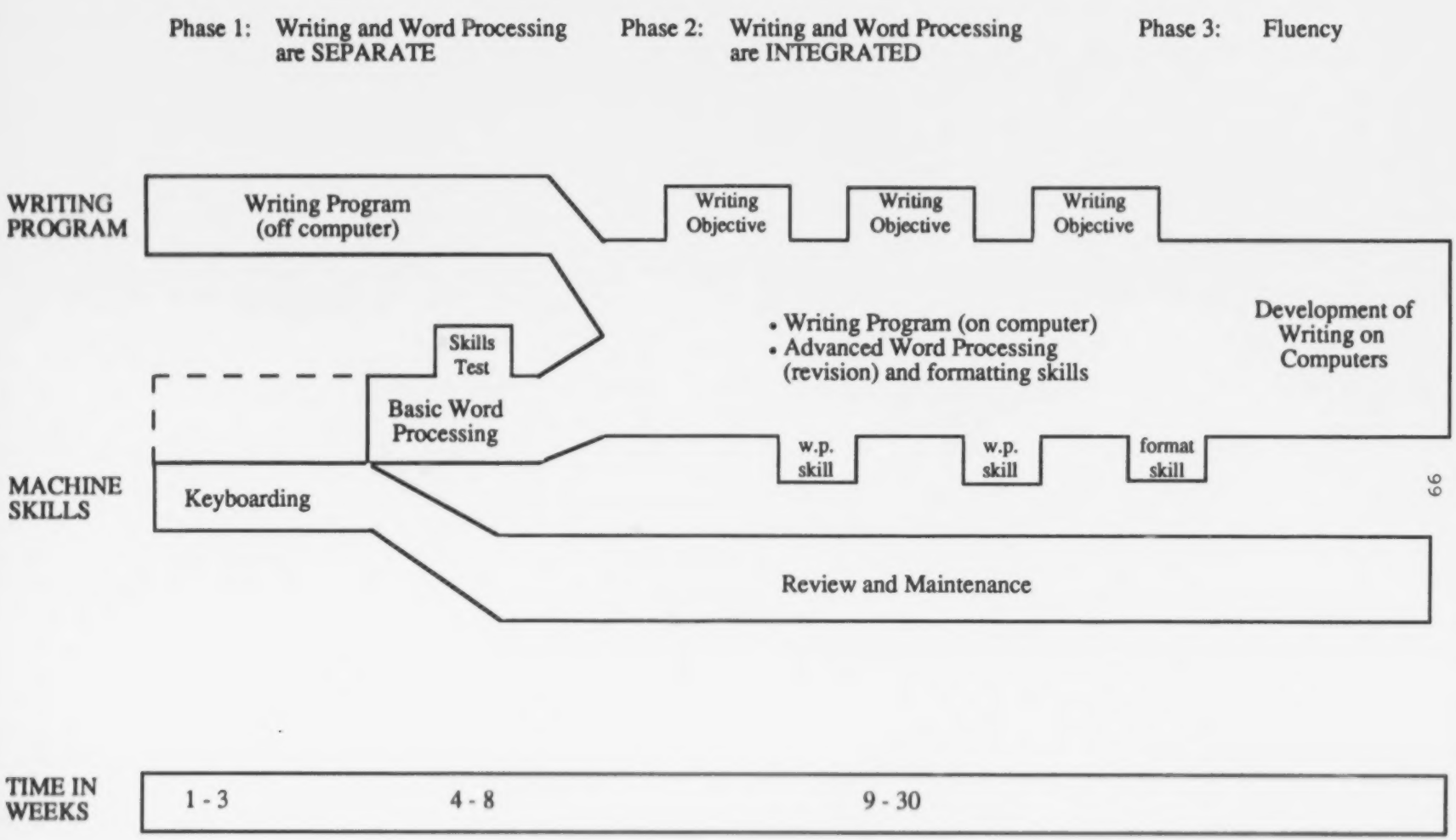


Figure 7

Word Processing Lessons

Lesson	Major Word Processing Skills	Language Arts	Activity Disk Exercise
	Basic Skills		
1. Meet the Writing Machine	Boot Up Create a file	Dialoguing	-------
2. Saving It	Save a File Backward Delete Cursor Placement	Writing informal paragraphs	--------
3. Getting It Back	Retrieve (load) Resave a file	Adding to a paragraph	---------
4. Saving Multiple Files	Clear catalogue	Writing riddles and clues	----------
5. Mastering Save	SAVE (fluency)	More writing riddles and clues	---------
6. Mastering Retrieve	Retrieve (fluency)	Using clues to guess riddles	ZRIDDLE ZCLUE1, ZANSWER
7. Erasing Backwards	Backward Delete	Homonym recognition	7 HOM 1 7 HOM 2 7 HOM 3 7 VERY 7 REALLY 7 SPELL 1
8. Deleting and Retyping Letters	Use of SHIFT key Delete Retype	Capitalization rules	8 ROS 8 ERR 8 CAT 8 DAYS
9. Erasing and Inserting Words	Delete/Insert	Vivid word choice	9 SIMILE 9 MOUSE 9 SYN 9 INSERT 9 FRED
10. Printing	Printing	Sharing Writing	--------

Lesson	Major Word Processing Skills	Language Arts	Activity Disk Exercise
Basic Skills, Continued			
11. Formatting Titles and Paragraphs	Return Indent Center	Formatting for publication	11 LIZARD 11 TOOTH 11 FROGS 11 ESKIMO 11 SNOW 11 WHALE
12. Spacing and Punctuation	Delete Insert, Space bar Enhancing text	Formatting for publication	12 GENTLE 12 SNAKES 12 BABY
13. Block Erase	Deleting several lines of text	Recognizing extraneous sentences	13 BRAVE 13 ERASE 1 13 ERASE 2 13 TAG
14. Block Move	Rearranging text	Sequencing ideas	14 MOTHER 14 HIPPOS 14 MOVE 1 14 PLOT 1
15. Find/Replace/Search	Locating/replacing text	Spelling: word choice	15 SEN 15 OCT 15 ONETWO 15 SLALOM 15VERYSPEC 15 FIND2 15 MATH 15 FIND 1 15 FIND 3
Publishing Skills			
16. Editing	Deletion, retyping, insertion (fluency)	Final editing	----------
17. Printer commands	Enhancing text appearance	Formatting and publication	----------
Miscellaneous			
18. Deleting Files	Removing files from data disk	----------	----------

Cushman, Packard & Neale, 1987). Activities encompassed several genres and "research" techniques, for example: "Using Observation to Write Detailed Description," "Using Interviewing to Tell Other People's Stories," and "Using Memories to Write Personal Narrative." Although teachers made use of many of the ideas in these activities during the first year, by the second year they felt strongly the need to design and "own" their own writing activities. The assumption was that some parts of a writing activity might be best carried out away from the computer--for example, group brainstorming, webbing, illustrating, annotating a printout for revising and editing--and that teachers and students would make this judgment.

Individualized Help for Special Needs Students

Our experience during the resource room phase of the study taught us that LD students may need individualized help at all stages of the writing process and particularly at the beginning of a writing assignment. Teacher interventions need not be lengthy but need to happen early in the process, particularly when generating ideas, getting started writing, and finding a focus for reviewing and revising their work. Most LD students in our sample were receiving special services; however, the project required that students not be pulled out of the classroom during writing sessions for those services, and that, if possible, a specialist would provide monitoring and assistance in the classroom.

VARIATIONS IN PROGRAM IMPLEMENTATION ACROSS THREE SITES

Although the four classrooms reflected all five general elements of a computer-supported writing program, they varied in the level at which they implemented some of the elements. Figure 8 summarizes the characteristics of the classrooms around the five elements. The two Waverly classrooms are combined, since the

Figure 8

Implementation of Computer-Supported Writing Instruction in Three Sites

	WAVERLY	BROWN	CARVER
Writing Process Approach			
• Writing opportunities	Writing across all content areas. In language arts, composing and revising personal narrative and autobiography.	Writing in several content areas/ongoing use of journals. In language arts, composing several genres: fable/fairy tale.	Writing mainly in language arts. In language arts, composing short skills-oriented writing activities.
• Preparation/ pre-writing	Prepare students for writing through reading, discussion, role play, oral rehearsal, collaborative brainstorming and pre-writing.	Prepare students for writing through reading, discussion, role play and pre-writing.	Individual brainstorming just before composing. Use of "story starters."
• Sharing opportunities	Ongoing sharing of student work in teacher-guided sharing sessions, and peer conferencing; preparation of students to use conferencing and sharing procedures. Teacher shares own writing.	Some sharing of student writing in class and in small groups. Ongoing peer conferencing.	Occasional teacher-directed sharing with whole class. Recent introduction of peer conferencing.
• Writing procedures/ strategies	Teaching of writer's "craft" through teacher modeling and daily mini-lessons in writing. Teacher introduces concepts, strategies and skills.	Teacher introduces writing strategies and skills in large-group lessons.	Teachers "troubleshoot"--respond to problems and needs identified by students.

	WAVERLY	BROWN	CARVER
• Revision focus	Targeted, incremental revision. Focus on both style/content and editing issues.	Focus on both style/content and editing issues.	Focus on editing issues; also some focus on sentence variety and descriptive detail.
Regular Access to Computer for Writing	3-4 writing sessions/week.	3 writing sessions/week.	3 writing sessions/week.
Integrating Computer into Writing Activities	Composing and revising long narratives (several pages) on computer.	Composing and revising moderate-length genre pieces on computer.	Composing and revising short (1-3 paragraph) pieces.
Strong Knowledge of Machine Skills	Developed machine skills curriculum with EDC staff. Taught machine skills curriculum systematically.	Taught machine skills systematically.	Taught machine skills systematically.
Individual Help for LD Students	Regular, systematic help for LD students from specialist in lab. Computer specialist troubleshoots machine difficulties. Intern available for individual help.	Resource room teacher occasionally assists LD and non-LD students in lab and classroom.	Classroom teacher rotates with individual help during writing.

teachers did all of their planning together and used very similar approaches and materials. Some of the major differences across the four classrooms occurred in their use of a writing process approach; to illuminate those differences Figure 8 breaks out several specific features of the writing process approach: writing opportunity, preparation and pre-writing, sharing opportunities, the opportunity to learn writing procedures and strategies, and the focus of revision instruction.

Writing was a major part of the language arts programs in all four classrooms, and students composed, revised and edited all of their writing on individual computers a minimum of three class periods each week. All four teachers used the machine skills curriculum systematically through November, simultaneously carrying out writing activities with paper and pencil, then shifted students' writing to the computer in December. Because the Brown classroom teacher and computer specialist developed the machine skills curriculum with EDC staff in the summer prior to the second year, they were probably most familiar with the lessons.

The most substantial differences among the classrooms were in the ways they carried out a writing process approach and in the resources they had available for providing LD students with individual help. Brown and Carver students wrote extensively in all subject areas, while Waverly students carried out most of their writing within language arts. In the Brown and Carver classrooms, social studies dioramas and science reports as well as illustrated stories covered most available wall space. In the Brown classroom, writing projects from varied content areas also hung on lines strung from one side of the room to the other.

Writing activities varied across the three classrooms. Brown students wrote mainly personal narrative, including an autobiography with sections on babyhood, childhood, school days

and an imaginary future, which students composed and revised extensively through most of the spring. Carver students wrote a variety of fictional genres, including fables and fairy tales, and they composed and revised each assignment over a period of several weeks. Waverly students carried out a greater number of writing assignments, which were shorter in length and mostly descriptive of people or settings. In addition, they had a short autobiography project.

Brown and Carver students were prepared for each new writing assignment with extensive reading of published books, other students' writing, group "brainstorming" and individual pre-writing. The Brown teacher also frequently had students pair up to talk about their ideas just before beginning to write; when students were beginning a new assignment, the teacher kept them in the writing circle, talking about their ideas until they felt confident about starting to compose. Each Carver student kept a journal ("theme book"), where s/he jotted down ideas for writing, did "free writing" on topics of his/her choice and sometimes started first drafts. Waverly students used "story starters" (e.g., "What does your favorite room look like?") or individually brainstormed a list of words and phrases just before beginning a writing activity.

The classes differed in the extent to which the teachers provided direct instruction in writing and revision skills, and in how they followed up on that instruction. The Brown teacher regularly taught "mini-lessons" on skills such as writing leads or making transitions, then followed up on those skills through interactions with students during composing/revising sessions. The Brown teacher made a point of focusing LD students' attention on one revision issue at a time. Students might have repeated "encounters" with their drafts, successively elaborating the content, reviewing transitions, and correcting punctuation.

Stimulated by the example of the Brown teacher and by the availability of student printouts, the Carver teacher began in the second year to teach group revision lessons, often using an overhead projector to have the class work together on a student's draft. After the whole group lesson, he had students choose one area in which to make changes, "whether it's the beginning lead, middle leads, whatever it is, and then we just work on that." Rather than directly teaching writing skills, the Waverly teachers primarily took on a "troubleshooting" role--responding individually to the questions or issues students themselves raised during writing.

The three sites differed most dramatically in the kinds of sharing and response opportunities the teachers created. Creating a safe environment for peer response to writing was probably the Brown teacher's central goal. She worked at this goal by encouraging students to write for one another rather than for her. She minimized teacher-student conferences in the early months of the fourth-grade in order to place the emphasis on peer response, and she created extensive opportunities for whole class, small group, and partner sharing. She has an "author's corner" in her classroom--marked off from the rest of the room with tables, low book shelves and a thick rug--where students read and talk about their writing. She taught students general procedures for taking the role of author or audience in the sharing session. For example, students were to appreciate one another's work before offering a question or suggestion--"I like that you were 28 days late [being born], but I think your mother would react more." The author was to tell the group what kind of help s/he would most like. Beyond these guidelines, she encouraged students to respond spontaneously to one another's writing. She provided students guidelines for peer conferencing sessions and used the author's corner to have two students "replay" for the rest of the class a peer editing conference they had held the previous day. During the role play they talked

about the editor's concerns and suggestions and the author's decision about what to do with the editor's feedback. As a result of this extensive, ongoing sharing, students went into their revision sessions with highly specific feedback from each other about their writing. During writing sessions, Brown students often took advantage of the open computer screens to talk informally with each other about their writing.

In the second year of the project, as he integrated the computer more intensively into his writing program, the Carver teacher moved away from working mostly one-to-one with students, to carrying out whole-class revision sessions and some peer conferencing. To introduce students to peer conferencing, he modeled it with another teacher (he had observed the Brown teacher do this in a teaching meeting) and developed peer conferencing guide sheets for students to use in pairs and in small group conferencing. Waverly students occasionally shared their writing with the whole class, with the teacher structuring and directing students' responses and, in some cases, reading students' writing aloud for them. Peer conferencing was limited in Waverly, and students often focused on mechanics when they did confer.

The Brown classroom differed from the other classrooms in the level of resources available for individual help to LD students. The Brown teacher worked with a "team" in her writing program that included herself, a part-time remedial specialist, a computer specialist when the class was in the lab, and occasional student interns. The remedial specialist was present two days a week, working systematically with LD students on targeted composing or revising issues. The computer specialist was available to the whole class for troubleshooting machine skill problems. A resource room teacher or her aide was present in the Carver classroom for one or two classes per week, responding to LD and non-LD students' difficulties as they arose. The Carver

teacher had the assistance of the resource room one to two days a week. She responded to students' needs on a "trouble shooting" basis. Each of the Waverly teachers managed their small classrooms of 15 students alone to "troubleshoot" as problems arose.

In summary, students in all three sites were carrying out writing on the computer in language arts. Brown and Carver differed from Waverly in carrying out long-term writing projects, for which students were extensively prepared, and in directly teaching skills and strategies related to the "craft" of composing and revising. Both the Brown and Carver teachers created a pervasive atmosphere of generating and sharing ideas and texts, and intimate opportunities for talking about writing. The main difference between the Brown and Carver classrooms lay in the greater opportunity Brown LD students had for sharing their writing and in the systematic quality of the individual feedback they received around highly specific writing issues.

IV: RESULTS

Results are presented here in three sections; the first section reports the results of the writing assessment, the second section presents the Harter Self-Perception data, and the third reports information obtained from the Student Writing Questionnaire. The results for each of the three sites are presented separately. We did not aggregate the data because the three sites were located in demographically varied communities, and the implementation of computer-supported writing instruction varied in some important ways across the three sites. Rather than regarding the three sites as replications of the same treatment in different locations, the current study assesses the potential impact of computers within somewhat varied writing programs. We have organized the results within each section around the three major questions of the study: Do fourth-grade students' writing quality, self-concept and attitudes toward writing vary as a function of treatment group (computer vs. pen and paper), student type (LD vs. non-LD), and the contrast of treatment group and student type (LD treatment vs. LD comparison)?

IMPACT ON NARRATIVE WRITING QUALITY

Brown

Treatment vs. Comparison

Table 5 presents the results of the main statistical analyses of the writing scores for the students in the Brown classrooms. There were no significant differences in the overall levels of performance between the treatment and comparison classrooms; however, the overall growth rate for the treatment class was significantly greater than the growth rate for the comparison class. These results for the Brown classrooms are presented in Table 6 and Figure 9. Table 6 shows the mean scores for the

Table 5

Brown: Summary of Statistical Tests on Writing Quality Scores for Students

	Levels of Performance [a]			Rates of Growth			Growth Variability		
Contrasts	Est [b]	t	p	Est	t	p	Est	t	p
Treatment vs. Comparison df (1,41)	-.01	.04	.967	.31	2.23	.031*	-.04	.50	.612
LD vs. Non-LD df (2,40)	-1.02	3.22	.003**	-.07	.41	.686	-.18	2.31	.026*
LD Treatment vs. LD Comparison df (3,39)	-.13	-.20	.842	.37	1.11	.27	-.09	.55	.585

Note: Contrasts were entered in the order specified.

[a] Estimates of mid-year performance based on individual student growth trajectories
[b] Estimates of the differences between the groups specified in the contrast

*$p < .05$
**$p < .01$

Table 6

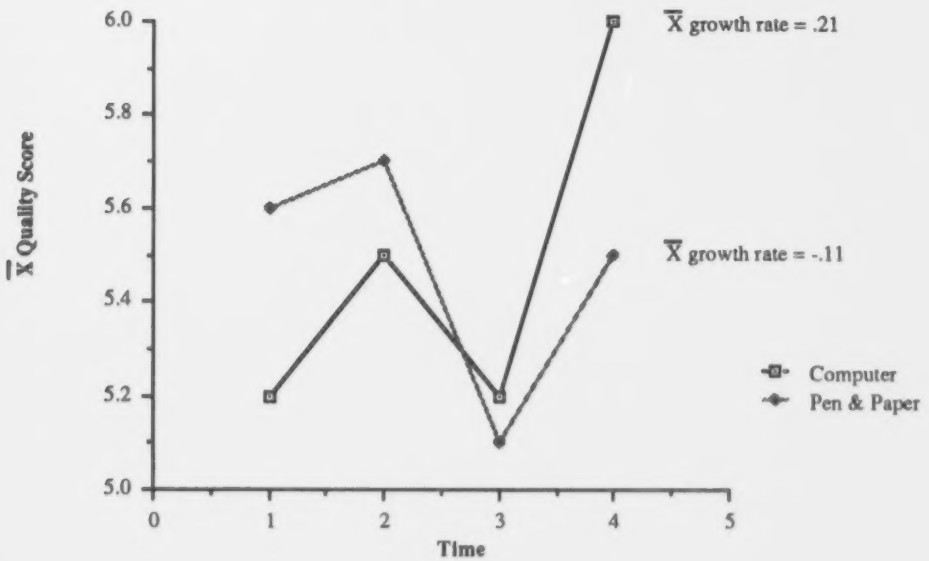
Brown Narrative Writing Quality Scores for 4th Grade Students in a Computer vs. Pen and Paper Writing Program

Time	Mean Quality Score*	
	Computer (n=21)	Pen & Paper (n=22)
Time 1	5.19	5.64
Time 2	5.52	5.73
Time 3	5.19	5.09
Time 4	6.00	5.50

*Possible writing quality score range is 2-8.

Figure 9

Brown Writing Quality Scores for 4th Grade Students in a Computer vs. Pen and Paper Writing Program



treatment and comparison groups on each of the four writing samples. Note that the differences between the average scores of the treatment and comparison groups were not substantial, with the comparison group showing slightly higher scores at times 1 and 2, and the treatment group showing slightly higher scores at times 3 and 4. The overall difference in the levels of performance was very small. On the other hand, Figure 9 shows that the trends over time in the scores for the two classrooms were different. The treatment class showed a definite trend of positive growth. The average growth rate for the treatment classroom was .21, for an overall growth rate of nearly two-thirds of a writing quality point over the six-month study interval. In contrast to the treatment classroom's positive growth, the comparison class averaged a negative growth rate of -.11, a decrease of three-tenths of a writing quality point from October to May. This difference in growth rates between the classrooms is statistically significant.

Figure 10 shows the distribution of each classroom's growth rates. In each class there was substantial variability among students, with somewhat greater variability among students in the treatment classroom. There, individual rates varied from a low of -.7 to a high of 1.3. Individual growth rates in the comparison classroom ranged from -.8 to .8.

LD vs. Non-LD

Table 7 and Figure 11 show the performance of the LD and non-LD students. In both classrooms, LD students clearly performed at a lower level than the non-LD group. But the figure also shows (perhaps more clearly in looking at the treatment group results) that while the overall <u>levels</u> of performance were lower, the <u>rates of growth</u> for LD students were quite similar to those of their non-LD classmates. Table 5 indicates that while the LD students' average level of performance was significantly lower

Figure 10

Brown: Box Plot Distribution of Writing Quality Growth Rates

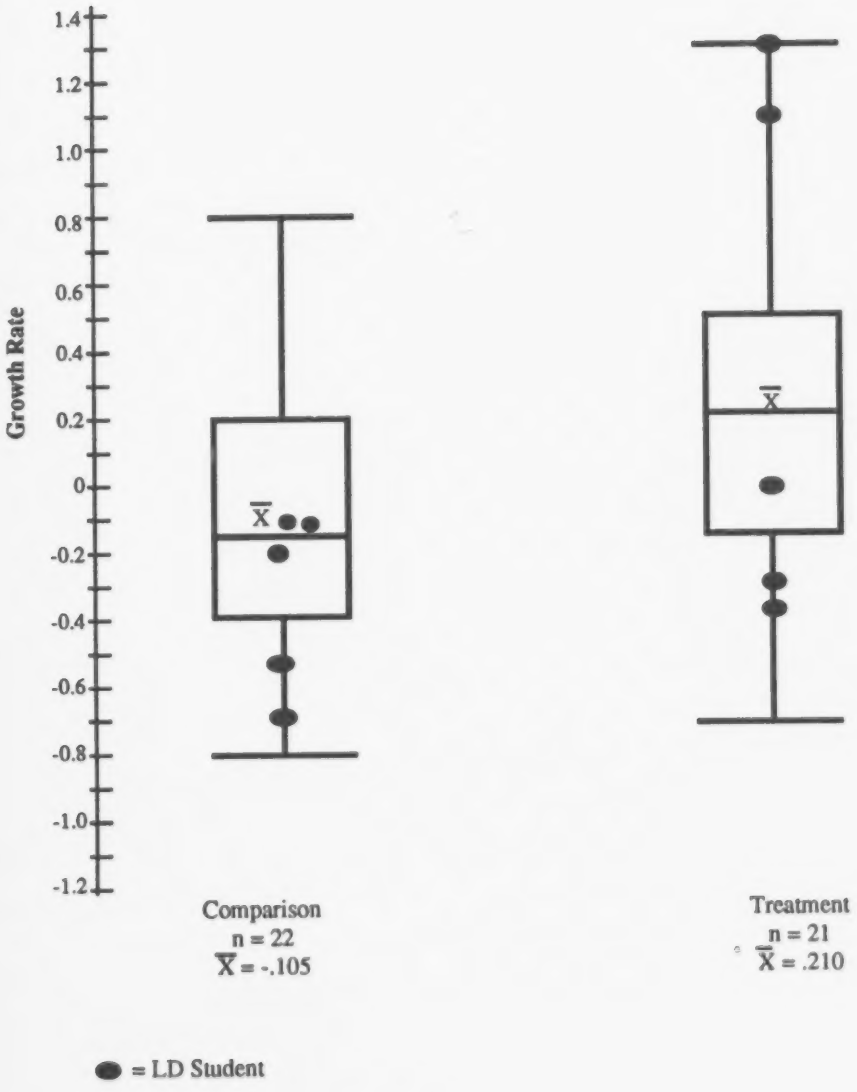


Table 7

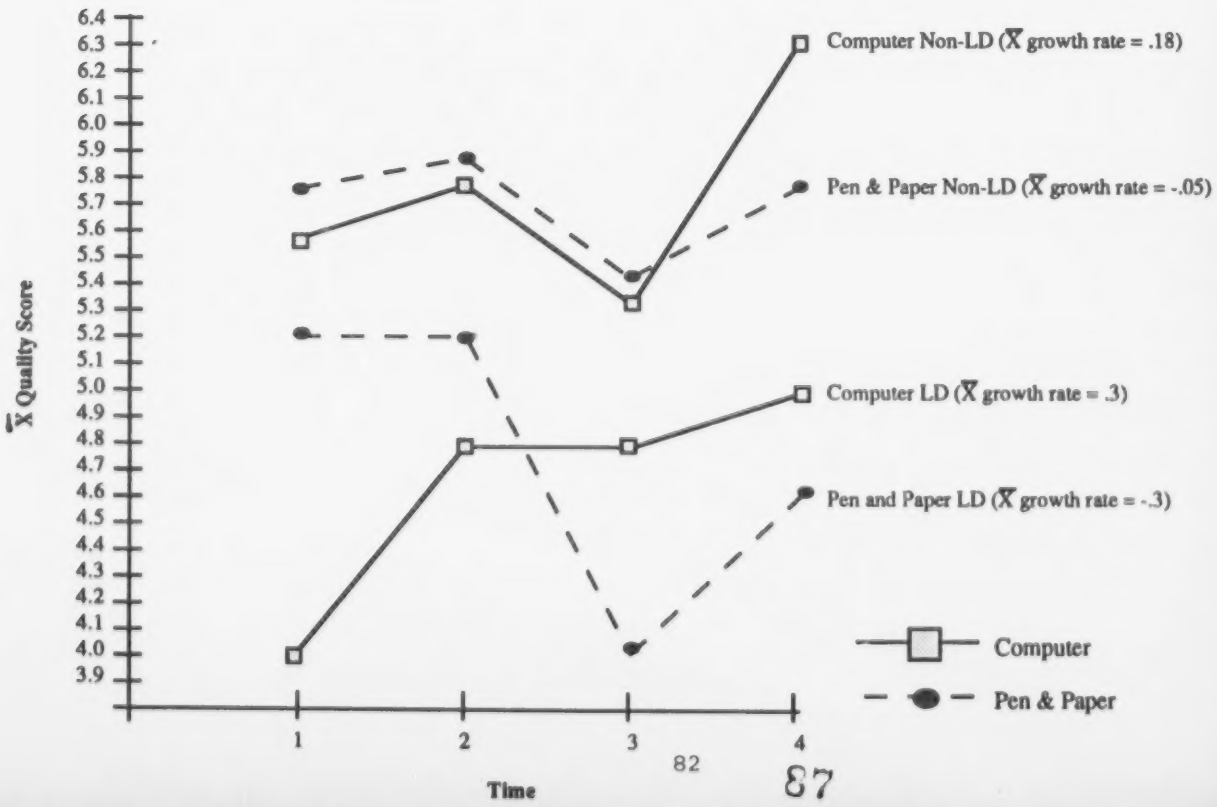
Brown Writing Quality Scores for LD vs. Non-LD 4th Grade Students in a Computer vs. Pen and Paper Writing Program

Time	Mean Quality Score*			
	Computer		Pen & Paper	
	Non-LD (n=16)	LD (n=5)	Non-LD (n=17)	LD (n=5)
Time 1	5.56	4.00	5.76	5.20
Time 2	5.75	4.80	5.88	5.20
Time 3	5.31	4.80	5.41	4.00
Time 4	6.31	5.00	5.76	4.60

*Possible writing quality score is 2-8.

Figure 11

Brown Writing Quality Scores for LD vs. Non-LD 4th Grade Students in a Computer vs. Pen and Paper Writing Program



than that of their non-LD peers, there were no significant differences in the growth rates between LD and non-LD students. On the average, LD students achieved a growth rate that was only .07 lower than that of their non-LD peers, for an overall difference of about two-tenths of a writing quality point from October to May. LD students averaged 0 growth, with individual rates ranging from -.7 to 1.3. Non-LD students averaged a slightly positive growth rate of .07, with rates ranging from -.8 to .9. Figure 10 highlights the distribution of the LD students' growth rates so they may be compared to the classroom distributions.

LD Treatment vs. LD Comparison

Because the LD samples were so small (five students per classroom), we looked at both the unadjusted and the adjusted results from the statistical analyses. Figures 10 and 11 show these results, and in Figure 10 we have highlighted the scores for the Brown LD students. The LD students in the treatment classroom averaged a positive growth rate of .3 per time interval, for a .9 quality point difference during October to May. As shown in Figure 10, three of the LD students showed positive growth and two showed negative growth. There was considerable variation within the LD treatment group, with rates ranging from -.4 to 1.3. In contrast, the LD students in the comparison group averaged a negative growth rate of -.3, for a .9 writing quality point decrease over the course of the study. All five of the LD students in the comparison group experienced negative growth rates, with a range in rates from -.7 to -.1.

While the unadjusted difference between the treatment and comparison LD groups is large, the statistical model testing for differences indicated that this difference was not significant after adjusting for the other factors in our model (see Table 5). After adjusting for the other comparison factors, the difference

between the growth rates of the LD students in the two classrooms is reduced in magnitude from the unadjusted difference of .6 to an adjusted difference of .37. Given the very small number of LD students and the substantial variability across the LD sample, the differences between the treatment and comparison classes for LD students was not large enough to produce statistically significant results.

To complete our analyses of the writing quality data, we looked at how the groups compared in terms of the within-individual variability in performance. We analyzed this by determining how well each student's scores fit the performance estimates from the regression model for each student's growth rate. Some students showed consistent patterns that fit the regression estimates quite closely. Others showed wide swings of performance around their overall growth rates. When we compared different groups of students, we found that there were no significant differences in the variability of performance between the treatment and comparison classrooms, and no significant differences between the LD and non-LD students (see Table 5). The LD students proved to be just as consistent (or inconsistent) in their patterns of growth as their non-LD classmates. Table 8 presents the means for the treatment and comparison classes and the LD and non-LD students.

As a final technical note, we used the variability estimates for each student to check on the overall comparisons carried out here by using weighted regression procedures. Weights for the cases were varied according to the standard error of the OLS regression model for each student. It is possible for these weighted results to produce a different picture than the unweighted results. This is particularly likely when subjects with greatest amounts of "error" or variability are found in one classroom or subgroup being compared. In our analyses, however, the patterns of results using the weighted regression procedures were very

Table 8

Brown 4th Grade Students' Mean Variability in Writing Quality Performance

		Variability in Performance	
Classes	(n)	$\overline{X}$	(SD)
Treatment	(21)	.39	(.23)
Non-LD	(16)	.44	(.23)
LD	(5)	.21	(.07)
Comparison	(22)	.42	(.24)
Non-LD	(17)	.46	(.25)
LD	(5)	.32	(.13)

consistent with the results from the unweighted or standard regression procedures we report here.

Carver

Treatment vs. Comparison

Similar to the results in the Brown classrooms, there were no differences in the overall levels of performance between the Carver treatment and comparison classrooms (see Table 9). The growth rate for the treatment classroom was slightly higher than the growth rate for the comparison classroom, although the difference was not statistically significant. Table 10 presents the mean writing quality scores for the treatment and comparison classes, Figure 12 illustrates the trends in writing quality growth, and Figure 13 shows the distribution of growth rates for the classrooms. The treatment class averaged a .29 growth rate per interval, for an overall gain of approximately nine-tenths of a writing quality point from October to May. Individual growth rates ranged from a low of -.8 to a high of 1.9. The comparison class averaged a .11 growth rate, for an overall gain of about one-third of a point over the time period of the study. There was an even greater range in individual growth here, with rates ranging from -1.0 to 1.5.

LD vs. Non-LD

Table 11 also shows the contrast between the performance of the LD and non-LD students in Carver. As expected, there were significant differences in the average levels of performance between the LD and non-LD students (see Table 9). Consistent with the results from Brown, however, and shown in Figure 14, the LD students in the Carver classrooms achieved higher growth rates overall than their non-LD classmates--exceeding the growth rate of the non-LD students by nearly one-quarter of a quality

Table 9

Carver: Summary of Statistical Tests on Writing Quality Scores for Students

	Levels of Performance[a]			Rates of Growth			Growth Variability		
Contrasts	Est[b]	t	p	Est	t	p	Est	t	p
Treatment vs. Comparison df (1,41)	-.03	.13	.899	.18	1.08	.285	.08	1.19	.242
LD vs. Non-LD df (2,40)	-.92	2.97	.005**	.30	1.43	.162	.01	.07	.945
LD Treatment vs. LD Comparison df (3,39)	.26	.42	.678	-.43	1.04	.306	-.01	.07	.948

Note: Contrasts were entered in the order specified.

[a] Estimates of mid-year performance based on individual student growth trajectories
[b] Estimates of the differences between the groups specified in the contrast

*$p < .05$
**$p < .01$

Table 10

Carver Writing Quality Scores for 4th Grade Students in a Computer vs. Pen and Paper Writing Program

Time	Mean Quality Score*	
	Computer (n=21)	Pen & Paper (n=22)
Time 1	5.48	5.73
Time 2	5.62	5.55
Time 3	5.48	5.95
Time 4	6.48	5.95

*Possible writing quality score range is 2-8.

Figure 12

Carver Writing Quality Scores for 4th Grade Students in a Computer vs. Pen and Paper Writing Program

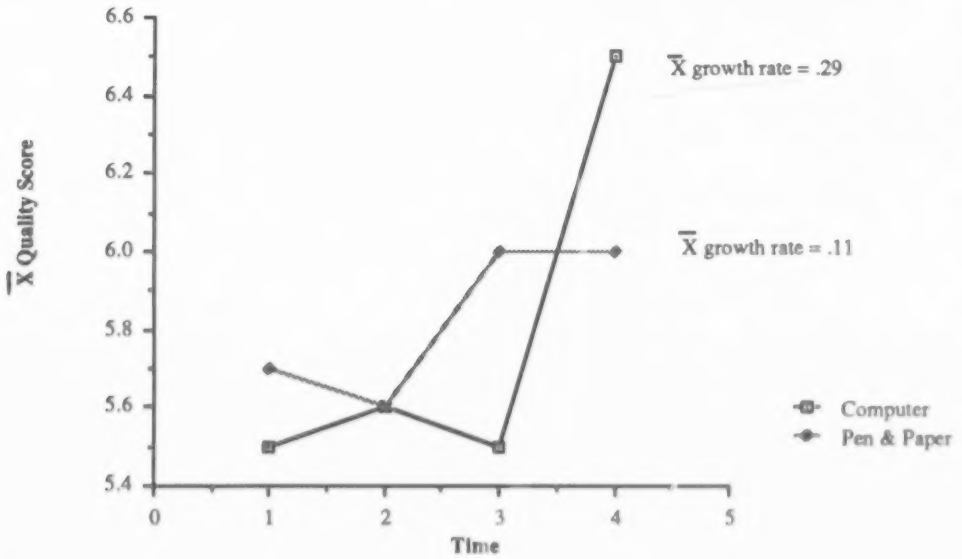


Figure 13

Carver: Box Plot Distribution of Writing Quality Growth Rates

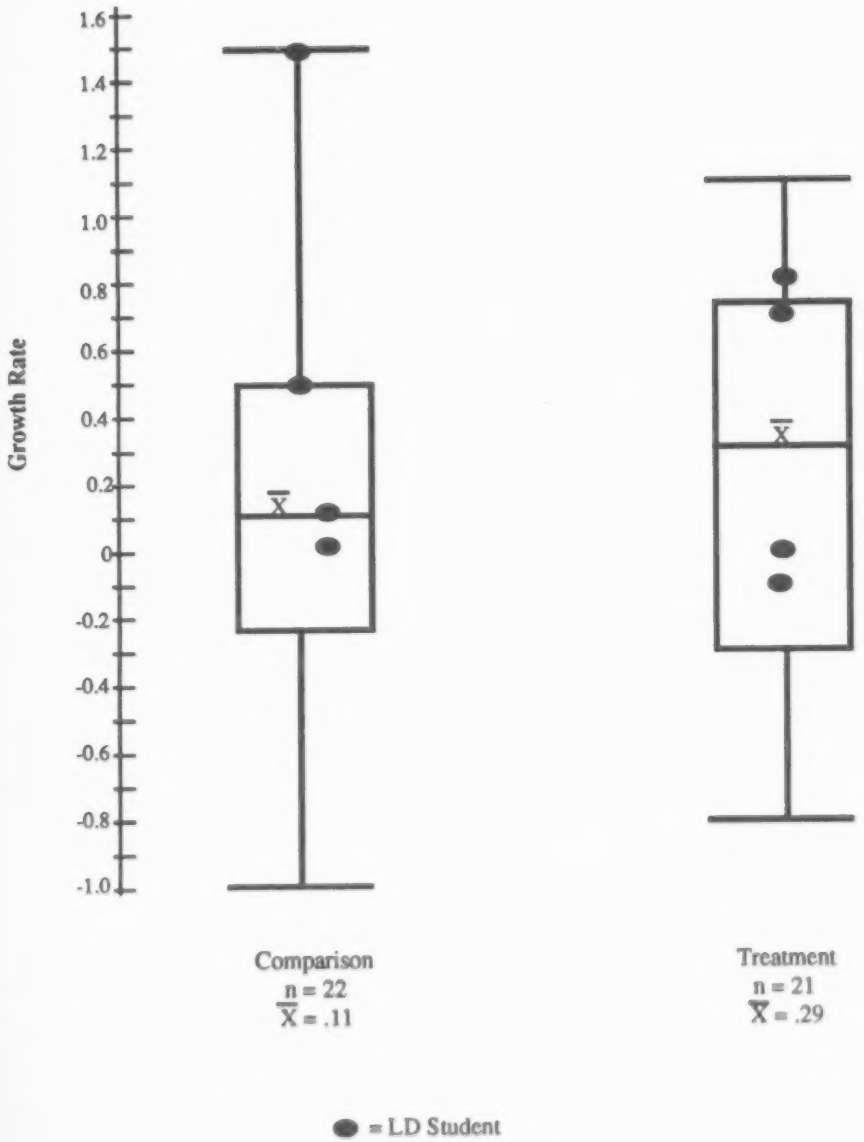


Table 11

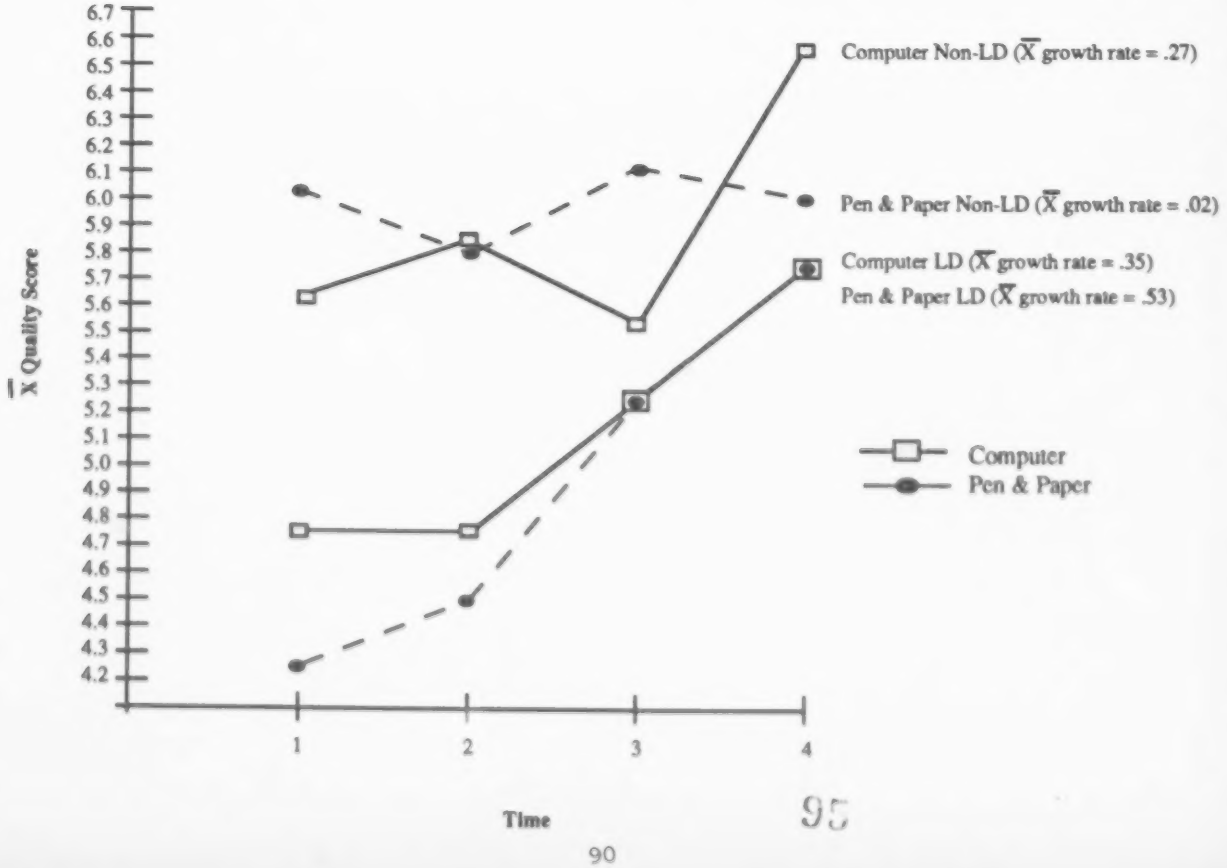
Carver Writing Quality Scores for LD vs. Non-LD 4th Grade Students in a Computer vs. Pen and Paper Writing Program

Time	Mean Quality Score*			
	Computer		Pen & Paper	
	Non-LD (n=17)	LD (n=4)	Non-LD (n=18)	LD (n=4)
Time 1	5.65	4.75	6.06	4.25
Time 2	5.82	4.75	5.78	4.50
Time 3	5.53	5.25	6.11	5.25
Time 4	6.65	5.75	6.00	5.75

*Possible writing quality score range is 2-8.

Figure 14

Carver Writing Quality Scores for LD vs. Non-LD 4th Grade Students in a Computer vs. Pen and Paper Writing Program



point--although this difference was not statistically significant.

LD Treatment vs. LD Comparison

Finally, the results show that there were no significant differences in the performances of the LD students in the treatment class compared to the performance of LD students in the comparison class. Table 9 shows that after controlling for other factors, the LD students in the treatment classroom had a growth rate .43 lower than that of the LD students in the comparison classroom, a difference that was not statistically significant.

Figure 13 shows the distribution of the growth rates for both classrooms, and the growth rates for the LD students are highlighted. The box plot shows that the higher average performance of the LD students relative to that of the non-LD group, as well as the higher average performance of the LD students in the comparison group, is heavily influenced by a single LD comparison student who achieved a high growth rate of 1.5. With the exception of this student, the LD students in the comparison and treatment classes appeared to experience similar rates of growth. Individual growth rates ranged from -.1 to .8 in the LD treatment group and from 0 to 1.5 in the LD comparison group.

As in our analyses of the Brown classrooms, we found no significant differences across classrooms or across types of students in variability of student performance (see Tables 9 and 12). The results of analyses using weighted regression procedures were virtually identical to the results presented here.

Table 12

Carver 4th Grade Students' Mean Variability in Writing Quality Performance

		Variability in Performance	
Class	**(n)**	$\overline{X}$	**(SD)**
Treatment	(21)	.55	(.22)
Non-LD	(17)	.55	(.24)
LD	(4)	.55	(.12)
Comparison	(22)	.48	(.20)
Non-LD	(18)	.47	(.21)
LD	(4)	.55	(.12)

Waverly

Treatment vs. Comparison

Tables 13 and 14 and Figure 15 present the results of the major comparisons among the Waverly students. As with Brown and Carver, there were no significant differences between the treatment and comparison groups in their overall levels of performance. Somewhat different from the other two sites, however, were the virtually identical mean growth rates for the Waverly classrooms. The mean growth rate for the treatment classroom was only .01 of a quality point higher than the growth rate for the comparison classroom. The box plot in Figure 16 shows that the distributions were comparable, with the range of individual growth rates in the treatment classroom slightly exceeding the range for the comparison classroom.

LD vs. Non-LD

Tables 13 and 15 and Figure 17 show the comparisons between LD and non-LD students. As with the earlier results, the LD students demonstrated significantly lower levels of performance than the non-LD groups, but the growth rate results showed a different pattern. The results here show that LD students obtained a growth rate that was .28 per time interval higher than that of the non-LD students. This difference was not statistically significant, although it does suggest a trend in favor of the LD students. The box plot in Figure 16 shows that none of the LD students fell in the lowest quartile, and that nine of the eleven LD students achieved a positive growth rate.

LD Treatment vs. LD Comparison

Tables 13 and 15 and Figures 16 and 17 also show the contrast between the LD students in the treatment classroom and the LD

Table 13

Waverly: Summary of Statistical Tests on Writing Quality Scores for Students

Contrasts	Levels of Performance [a]			Rates of Growth			Growth Variability		
	Est [b]	t	p	Est	t	p	Est	t	p
Treatment vs. Comparison df (1,51)	.03	.15	.882	.01	.05	.964	-.00	.00	.997
LD vs. Non-LD df (2,50)	-.64	2.56	.014**	.28	1.58	.121	-.05	.74	.461
LD Treatment vs. LD Comparison df (3,49)	.32	.62	.537	-.19	.52	.606	-.02	.10	.925

Note: Contrasts were entered in the order specified.

[a] Estimates of mid-year performance based on individual student growth trajectories
[b] Estimates of the differences between the groups specified in the contrast

*$p < .05$
**$p < .01$

Table 14

Waverly Writing Quality Scores for 4th Grade Students in a Computer vs. Pen and Paper Writing Program

Time	Mean Quality Score*	
	Computer (n=31)	Pen & Paper (n=22)
Time 1	5.55	4.95
Time 2	4.74	5.64
Time 3	5.81	5.64
Time 4	5.81	5.55

*Possible writing quality score range is 2-8.

Figure 15

Waverly Writing Quality Scores for 4th Grade Students in a Computer vs. Pen and Paper Writing Program

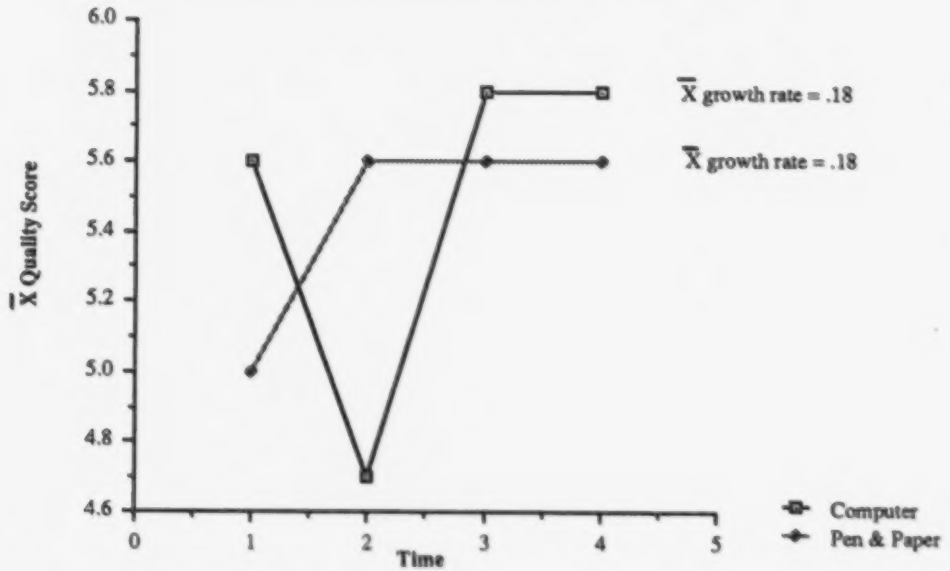


Figure 16

Waverly: Box Plot Distribution of Writing Quality Growth Rates

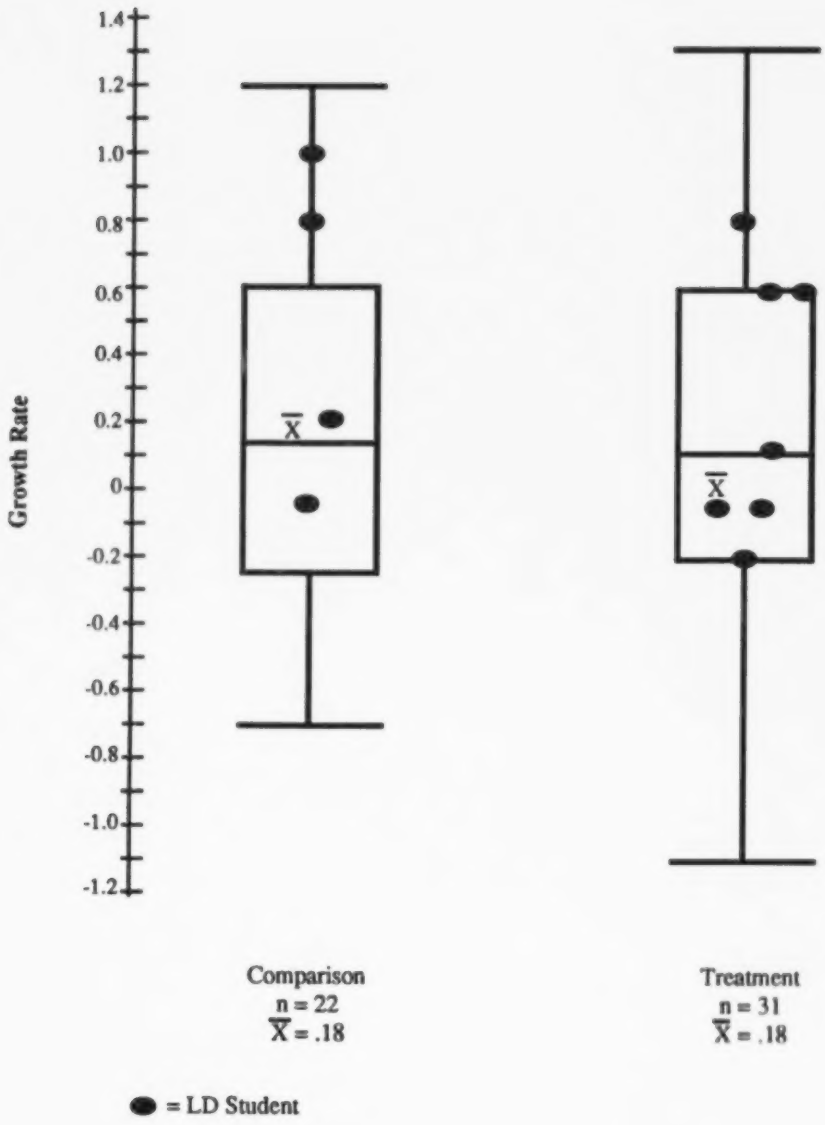


Table 15

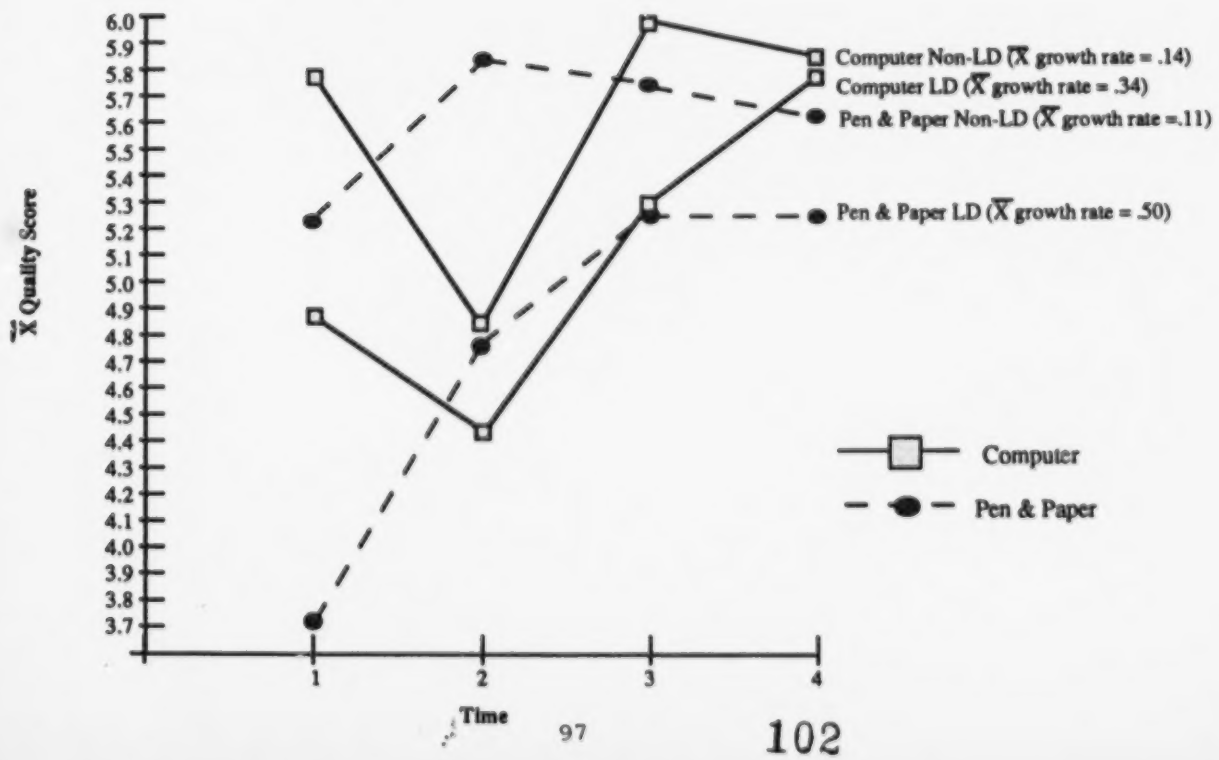
Waverly Writing Quality Scores for LD vs. Non-LD 4th Grade Students in a Computer vs. Pen and Paper Writing Program

Time	Mean Quality Score*			
	Computer		Pen & Paper	
	Non-LD (n=24)	LD (n=7)	Non-LD (n=17)	LD (n=5)
Time 1	5.75	4.86	5.22	3.75
Time 2	4.83	4.43	5.83	4.75
Time 3	5.96	5.29	5.72	5.25
Time 4	5.83	5.71	5.61	5.25

*Possible writing quality score range is 2-8.

Figure 17

Waverly Writing Quality Scores for LD vs. non-LD 4th Grade Students in a Computer vs. Pen and Paper Writing Program



students in the comparison classroom. The results show that there was no significant difference between the two LD groups in their levels of performance and their rates of growth. LD students in the treatment classroom obtained an average growth rate that was .19 lower than that of the LD students in the comparison classroom. The box plot in Figure 16 shows that the distributions of individual growth rates in the two classrooms are quite similar.

Consistent with results from the other two sites, there were no significant differences in the variabilities in performance (see Tables 13 and 16). The results of the weighted regression procedures were quite consistent with the results presented here.

COMPARISON OF THREE APPROACHES TO MEASURING CHANGE

Although we have focused mainly on our use of growth analyses, we also used several more traditional approaches to the same data. Table 17 presents analyses of the student writing quality scores using three different methods. We used the scores from time 1 and time 4 only to carry out a traditional pre-test/post-test difference or gain-score analysis. We used the difference scores to carry out the same main comparisons we addressed in our analyses of the growth scores. We also utilized the scores from all four time points to carry out a standard repeated-measures analysis of variance, including the writing quality scores as a within-subjects factor, and classroom (treatment vs. comparison) and student type (LD vs. non-LD) as between-subjects factors in the model. Table 17 summarizes these analyses, together with the corresponding results from our growth analyses.

Treatment vs. Comparison

Although results are generally consistent, care must be taken in interpreting some of them. In the Brown classrooms, the

Table 16

Waverly 4th Grade Students' Mean Variability in Writing Quality Performance

		Variability in Performance	
Class	**(n)**	$\overline{X}$	**(SD)**
Treatment	(31)	.46	(.19)
Non-LD	(24)	.47	(.19)
LD	(7)	.42	(.20)
Comparison	(22)	.46	(.16)
Non-LD	(18)	.46	(.17)
LD	(4)	.42	(.00)

Table 17

A Comparison of Three Approaches to Measuring 4th Grade Students' Writing Quality Growth

		Growth Modeling		Repeated Measures		Difference Score	
District	**Contrast**	**t**	**p**	**t**	**p**	**t**	**p**
Brown	Treatment vs. Comparison						
(n=42)	unadjusted [1]	2.23	.031*	----	----	2.25	.030*
	adjusted [2]	1.41	.166	.95	.419	1.54	.132
	LD vs. Non-LD adjusted	.40	.691	.23	.876	.35	.731
	LD Treatment vs. LD Comparison	1.11	.274	1.11	.348	.84	.405
Carver	Treatment vs. Comparison						
(n=42)	unadjusted	1.08	.285	----	----	1.37	.178
	adjusted	1.42	.162	1.78	.155	1.70	.098
	LD vs. Non-LD adjusted	1.42	.163	.72	.540	1.08	.287
	LD Treatment vs. LD Comparison	1.03	.306	.49	.687	1.08	.287
Waverly	Treatment vs. Comparison						
(n=52)	unadjusted	.05	.964	----	---	.82	.420
	adjusted	.20	.845	4.23	.006**	.58	.567
	LD vs. Non-LD adjusted	1.65	.106	1.12	.343	1.58	.120
	LD Treatment vs. LD Comparison	.52	.606	.29	.835	.28	.778

[1] unadjusted model (Growth = $\hat{B}_0 + \hat{B}_1$ treatment + E)
[2] adjusted model (Growth = $\hat{B}_0 + \hat{B}_1$ treatment + $\hat{B}_2$ LD + $\hat{B}_3$ LD treatment/LD comparison + E)

differences between the treatment and comparison groups are significant in both the gain-score and growth-model approaches, while the contrast in the repeated-measures analysis is not. The results of the classroom comparisons in the Carver site show similar levels of consistency, with all three approaches showing a trend--although not quite statistically significant--favoring the treatment classroom. The only notable discrepancy in the classroom comparisons occurs in Waverly. Both the gain-score and growth-model approaches show no differences across the classrooms, while the repeated-measures analysis indicates a significant difference between the treatment and comparison classes' performance over time. This was apparently due to the dip in performance of the treatment group at time 2 (see Figure 15). This dip at time 2 is not taken into account in the gain-score analysis, while it is "smoothed out" in the growth-model approach and contributes to increased variability.

LD vs. Non-LD

Regardless of analytic approach used, there were no significant differences between the LD and non-LD students' average growth rates. However, the comparison of the students' average performance level in the growth-model analysis and the repeated-measures analysis of average levels of performance (as opposed to performance across time) both yielded significant differences between LD and non-LD students, with LD students performing at a lower level than their peers.

LD Treatment vs. LD Comparison

All of the approaches were consistent in finding no strong evidence of differential effects on LD students versus non-LD students who were working with computers. There were no significant differences between LD students in treatment classrooms and LD students in other classes.

Thus the overall results from the growth-model analyses are generally consistent with the results of the more traditional approaches.

IMPACT ON SELF-PERCEPTION

The Harter Self-Perception Profile for Children measure was administered to the students in the Carver and Waverly classrooms only. Unlike the samples of students' writing, the self-perception measure was administered twice, at the beginning and again at the end of the period of the study. Our analyses focused on the same questions addressed in our analyses of the writing quality data, testing for differences in self-perception between the treatment and comparison classrooms, for differences between LD and non-LD students, and for differences between LD students in the treatment groups and LD students in the comparison groups.

The ANOVA results for Carver and Waverly are presented in Table 18 and the mean difference scores are presented in Table 19. The ANOVA results show that there were no significant differences for any of the comparisons at either of the two sites. The changes in self-perception scores were quite modest, and the changes did not appear to vary across classrooms or between LD and non-LD students.

IMPACT ON ATTITUDES TOWARD WRITING

As with the self-perception data presented above, the analysis of the Student Writing Questionnaires focused on changes in students' opinions. To limit the analyses and to provide some direction to our initial analyses of the questionnaire data, we concentrated our attention on three questions we thought were of particular relevance in this study.

Table 18

Statistical Analysis Results of Pre-Post Changes in 4th Grade Children's Self-Perception [a]

District	Contrast	Scholastic			Social			Global		
		Est[b]	t	p	Est	t	p	Est	t	p
Carver	Treatment vs. Comparison	-.07	.37	.712	-.11	.47	.642	-.18	.82	.418
	LD vs. Non-LD	-.41	1.74	.089	.10	.32	.754	-.49	1.76	.086
	LD Treatment vs. LD Comparison	.33	.71	.484	-.35	.55	.585	.22	.38	.703
Waverly	Treatment vs. Comparison	-.01	.06	.951	-.09	.48	.633	-.04	.22	.830
	LD vs. Non-LD	-.00	.00	.998	.07	.28	.779	.15	.63	.530
	LD Treatment vs. LD Comparison	-.84	1.60	.116	-.07	.14	.886	.08	.16	.873

Note: Contrasts were entered in the order specified.

[a] Self-Perception Profile for Children (Harter, 1985)
[b] Estimates of the differences between the groups specified in the contrast

*$p < .05$
**$p < .01$

Table 19

4th Grade Students' Pre-Post Changes in Self-Perception[a]

District	Class	(n)	Scholastic $\bar{X}$ (SD)	Social $\bar{X}$ (SD)	Global $\bar{X}$ (SD)
Carver	Treatment	(20)	.41 (.30)	.05 (.73)	.31 (.65)
	Non-LD	(16)	.46 (.31)	.06 (.79)	.39 (.62)
	LD	(4)	.20 (.14)	.00 (.48)	.00 (.78)
	Comparison	(21)	.47 (.75)	.15 (.74)	.49 (.72)
	Non-LD	(18)	.56 (.76)	.11 (.72)	.58 (.72)
	LD	(3)	-.03 (.42)	.40 (.98)	-.03 (.55)
Waverly	Treatment	(30)	.19 (.71)	.17 (.61)	.08 (.64)
	Non-LD	(23)	.26 (.78)	.16 (.68)	.03 (.69)
	LD	(7)	-.06 (.35)	.20 (.35)	.21 (.44)
	Comparison	(21)	.20 (.81)	.26 (.75)	.12 (.75)
	Non-LD	(17)	.10 (.81)	.24 (.81)	.10 (.75)
	LD	(4)	.63 (.76)	.35 (.53)	.20 (.89)

[a] Self-Perception Profile for Children (Harter, 1985)

- how much they enjoy writing
- how much they actually write (their overall writing production)
- how "good" they are at writing

We also looked at the opinions of students in the treatment classrooms about how the computer is (or is not) helpful to their writing process.

Figures 18, 19 and 20 compare the percentages of treatment and comparison students in each site and class who changed their perceptions, in a positive direction. The responses of the LD students are highlighted. Students who did not change their perceptions are not included in this display.

Treatment vs. Comparison

In all three of the computer-supported classrooms, students reported a greater enjoyment of writing at the end of the year than they reported at the beginning (see Figures 18-20). Specifically, between 26 and 33 percent of the students in the three treatment sites increased their perception of how much they enjoyed writing. In Brown and Waverly, the percent of students who increased their enjoyment of writing was more than twice that found in the comparison classes, while in Carver, the percent of students was comparable in the treatment and comparison classes. The percent of students who increased their perceptions of how 'good' they were at writing ranged from 10.5 to 36.7 in the treatment classes, and from 4.6 to 24.0 in the comparison classes. In Brown and Waverly, the percent of treatment students demonstrating an increase was more than twice that of the percent of comparison students. In Carver, the relationship is reversed, with approximately twice the percent of students in the comparison class demonstrating an increase. Students' perceptions of how much they write also varied across the three

sites. In Waverly, the percentage of students who increased their perception of how much they wrote was approximately twice that of the comparison class; in Brown, the levels were comparable; and in Carver, the percentage of treatment students who demonstrated an increase was approximately half that of the comparison class'. Additional analysis of those students who decreased their perception of how much they wrote indicated that in all three sites a greater percentage of students in the treatment classes decreased their perception of how much they wrote than in the comparison class.

LD Treatment vs. LD Comparison

Figures 18, 19, and 20 also compare the positive change in perceptions between LD students in the treatment and comparison classes. The results vary across the three sites. In Brown, three of the five LD students in the treatment class increased their enjoyment of writing, while none of the LD comparison students did. However, in Carver and Waverly, none of the LD students in the treatment class increased their enjoyment, while LD students in the comparison class increased their enjoyment. One LD student in each of the Brown and Waverly treatment classes and one LD student in the Carver comparison class increased their perception of how 'good' they were at writing. None of the LD students in the Brown and Waverly comparison class, or the Carver treatment class, evidenced an increase. Finally, two LD students in the Waverly treatment class, one LD student in the Waverly comparison class, and two LD students in the Brown comparison class increased their perception of how much they wrote.

Perceptions of the Computer

Across all three sites, more than 60 percent of the students in each class reported that the computer was helpful in revising and editing (see Figures 21, 22, and 23). More than 60 percent of

Figure 18

Brown: Percentages of Students Who Showed Positive Change in Their Perceptions about Writing

Figure 19

Carver: Percentages of Students Who Showed Positive Change in Their Perceptions about Writing

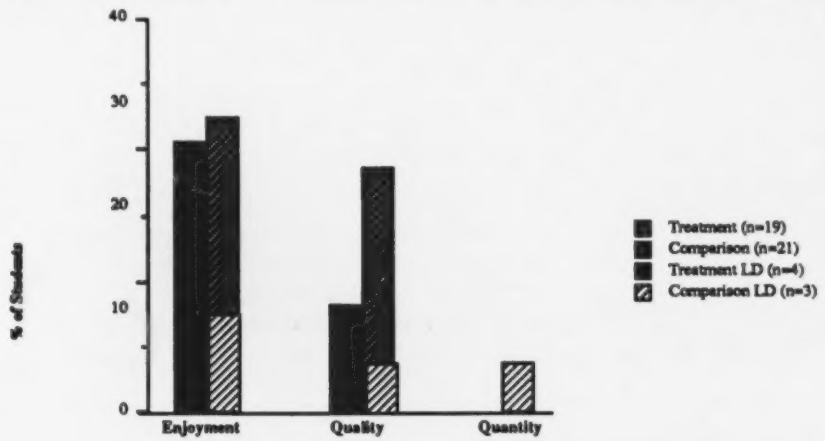


Figure 20

Waverly: Percentages of Students Who Showed Positive Change in Their Perceptions about Writing

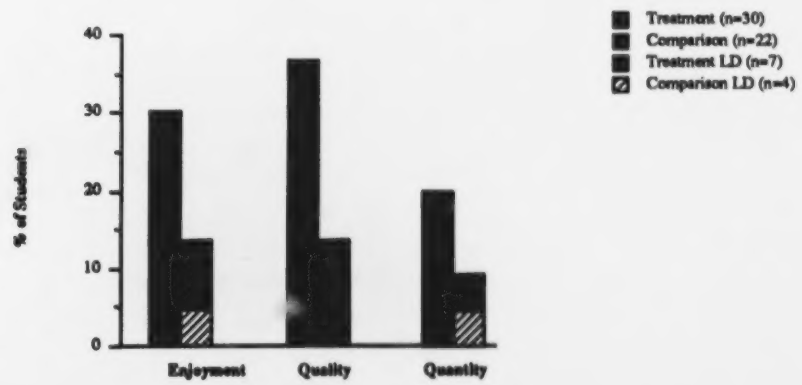


Figure 21

Brown: Percent of Students Who Rated the Computer as Helpful to Their Writing Process

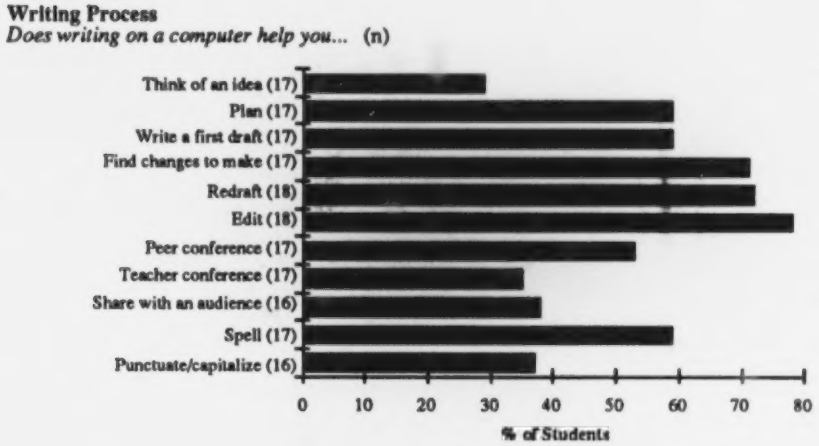


Figure 22

Carver: Percent of Students Who Rated the Computer as Helpful to Their Writing Process

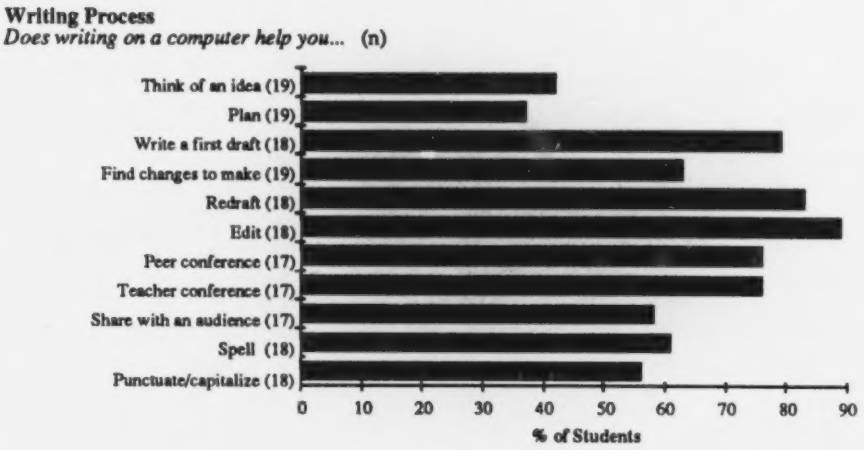
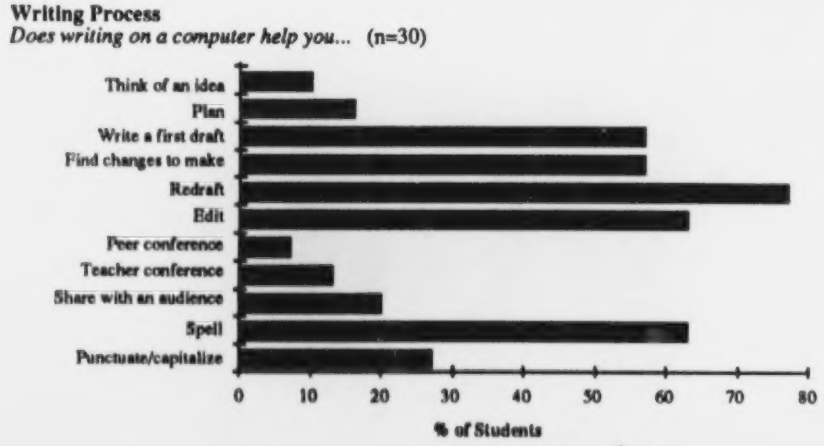


Figure 23

Waverly: Percent of Students Who Rated the Computer as Helpful to Their Writing Process



the students in Brown and Carver also thought the computer helped them find changes to make in their drafts, and more than 60 percent of the students in Carver thought the computer was helpful in composing a first draft, conferencing with peers and spelling. Among the Waverly students, more than 60 percent also found the computer helpful to their spelling.

V: DISCUSSION

SUMMARY OF RESULTS

The major analysis in this study was related to the impact of the classroom writing programs on students' writing quality. The site-by-site analyses focused first on the impact of the classroom writing programs on the writing quality of all students in the classrooms. There are several indicators that students in Brown's computer-supported classroom increased their writing quality over the school year more than did the students in the Brown paper-and-pencil classroom. The overall growth rate for the treatment classroom was significantly higher than that of the comparison classroom, using a growth-model analysis, and a traditional gains-score analysis supported that result. In Carver, the results also favor the computer-supported classroom over the paper-and-pencil classroom. Though the growth rate of the Carver treatment class was not statistically different from that of the Carver comparison class, students in the Carver treatment classroom grew the most, over the four assessment points, of all of the treatment and comparison classrooms. There were no differences between the treatment and comparison classrooms in Waverly.

The second focus of the analyses was the difference between LD and non-LD students across treatment and comparison classrooms in each site. In all three sites, the LD students performed at a significantly lower level than did non-LD students as might be expected. LD students' growth rates were similar to those of the non-LD students, however.

The third focus of the analyses was on the differential impact of the writing programs on LD students in the treatment classrooms versus LD students in the comparison classrooms. In Brown, we observed some differences in the growth rate of LD students in

the treatment and comparison classrooms. Though the small sample did not yield statistically significant results, analysis of the unadjusted data revealed practical differences between the two groups, with the growth rates of the LD students in the computer-supported classrooms exceeding the growth rates of the LD students in the paper-and-pencil classrooms.

The study also investigated the impact of the programs on students' self-perception and on their attitude toward writing. There were no differences between classrooms or student groups in Harter Self-Perception results. In terms of attitudes towards writing, as measured in the student questionnaire, we found a mixed pattern of results. More students in the Brown and Waverly classrooms increased their enjoyment of writing and their perception of how good they are at writing. In Carver, a similar percentage of students in the treatment and comparison classrooms increased their enjoyment of writing while a greater percentage of students in the comparison classroom increased their perception of how good they are at writing. In all three sites a greater percentage of students in the treatment classes decreased their perception of <u>how much</u> they wrote.

In terms of LD students' attitudes, three of the five Brown LD students increased their enjoyment of writing, while none of the LD students in the comparison classroom did. In Carver and Waverly none of the LD students in the treatment class increased their enjoyment of writing, while two Carver LD students and one Waverly student in the comparison classroom increased their enjoyment. One LD student in each of the Brown and Waverly treatment classes and one LD student in the Carver comparison classrooms increased their perception of how good they are at writing. None of the LD students in the Brown and Waverly comparison classes or the Carver treatment class evidenced an increase.

The finding that the treatment students in general perceived themselves as writing less by the end of the year than did comparison students holds for most of the LD students in the treatment classrooms as well.

INTERPRETATIONS OF RESULTS

The results from Brown and Carver show modest support for a computer-supported writing environment. A number of interpretations could account for this. The results may have occurred solely by chance, rather than from any differences in the impact of the instruction taking place in the classrooms. Another possible interpretation is that students in the Brown treatment classroom, and to a lesser extent students in the Carver treatment classroom, received a greater amount of individualized help for their writing than did students in the comparison classrooms in those sites, and that this help contributed to their greater overall growth in writing quality. In Brown, the computer-supported classroom had a specialist two class periods each week who focused mainly on LD students, and an intern who was likely to rotate among all students. However, the comparison teacher at Brown also provided continuous individualized help to students during writing; in addition, his LD students were receiving special services outside the classroom each week and overall might have been receiving as much or more individual help than LD treatment students who shared the specialist during her two hours in the classroom. Even if LD students received about the same amount of individual attention to their writing in the two classrooms, it is possible that the LD treatment students particularly benefited from receiving their help within the classroom, in the context of their writing process program, rather than in a separate setting. The resource room teacher provided general support in the Carver treatment classroom up to two class periods per week, while the Carver treatment teacher did not have additional assistance.

A third interpretation is that the computer, in combination with both 1) an instructional approach that leads to extensive composing and revising, and 2) individualized help for LD students, contributed to the gains in writing quality in the Brown and Carver treatment classrooms. This interpretation offers a reasonable explanation for both the differences between the Brown treatment and comparison classrooms and the differences between the Brown and Carver results. In Brown, both treatment and comparison teachers were highly experienced writing teachers and used similar approaches--they were well-matched for the purposes of the study. The major difference between the two was the writing tool, which in the treatment classroom enabled students to take full advantage of the extensive emphasis on composing and revision. It is clear from observation data in the treatment classroom that the treatment teacher presented a succession of mini-lessons on expanding and revising students' drafts, and that students took advantage of this "targeted" approach to composing/revising over many "encounters" with their drafts. "Encounters" were essentially writing episodes of a few minutes or a substantial part of a class period in which students focused on one aspect of their draft, made changes, then saved the revised draft under a new file name. Student disks and printouts indicate that students had as many as twenty different encounters, and produced that many "drafts," for some sections of their autobiography. In an interview, the Brown teacher reported that she thought the availability of the computer as the writing tool caused her to provide even more revision opportunities than she had prior to using computers. Whether or not the computer influenced the Brown treatment teacher to provide more revision instruction or opportunities than the comparison teacher, the students in the treatment classroom had a tool that may well have enabled them to take greater advantage of the revision instruction provided them. In contrast, the ability of the comparison students to pursue revision opportunities was limited by their writing tool.

The third interpretation of the greater impact of the treatment classroom in Brown students' overall writing quality, then, is that the computer enhanced an instructional approach that encourages students to expand and revise their writing. While both treatment and comparison teachers provided ongoing instruction in and opportunities for expansion and revision, the computer may have enabled students in the treatment group to take greater advantage of those opportunities. And the presence of the computer may have led the teacher to focus even more intensively on revision, knowing that students could take advantage of the instruction.

The availability of individualized help in the Brown treatment classroom would have further enhanced the LD students' ability to take advantage of an emphasis on expansion and revision. The combination of explicit feedback on their writing, a person to provide additional guidance when needed and a writing tool to facilitate making changes probably all contributed to the higher level of growth in the treatment class in general, and to the higher level of growth in the LD treatment students than in the LD comparison students.

As the Treatment section suggests, the Carver teacher's implementation of a computer-supported writing approach was similar to that of the Brown teacher in several respects. And the Carver treatment classroom was clearly "successful" in relation to other classrooms in the study, since the Carver students showed the highest final scores in the NAEP assessment and the greatest change from the first to the fourth assessment. Two factors might possibly explain why the results from the Carver site showed similar, but not statistically significant, trends to those at Brown. One factor may be Carver's approach to providing revision instruction, which was primarily through whole-class "mini-lessons" rather than through the intensive, individual sharing and feedback sessions created by the Brown

teacher. Carver students probably received less individual help during writing than did the Brown students. Although a resource room teacher was frequently present, she played mainly a "troubleshooting" role, rather than providing an intensive, ongoing "program" of assistance to LD students.

The absence of stronger differences between the computer-supported and paper-and-pencil classrooms in Carver may be due to an issue raised in the Methods section--the possible greater congruence in the comparison classroom between the teacher's instructional approach and our writing assessment measure. While the treatment teacher engaged students in extensive preparation, development of personally relevant topics, pre-writing, composing, revision and finally editing, students in the comparison class wrote one short piece each week on a topic assigned by the teacher. Students often completed a draft in one day and then submitted the draft to the teacher, who made editing and occasionally revising suggestions. The NAEP assessment, which provides students with a topic and gives them one class period in which to produce a draft, may have been more consistent with the kind of writing that students in the comparison classroom were learning to do.

The absence of any impact of the computer-supported writing classroom in Waverly may possibly be attributable to the use of an instructional approach in both treatment and comparison classrooms that was not particularly enhanced by the use of computers. Observation and interview data from treatment teachers and interview and writing sample data from comparison teachers suggest that teachers in both conditions were using very similar approaches to teaching writing. Though their methods had elements of a "process" approach, their writing assignments tended to take the form of brief "writing activities" that involved less extensive composing, sharing, collaborating and revision than we observed in both Brown classrooms and the Carver

treatment classroom. In addition, the Waverly teachers provided less direct instruction in revision than did the Brown and Carver teachers.

The kind of revision students carried out, which generally took the form of substituting more descriptive words or editing for spelling and mechanics, might be as easily managed with paper and pencil and one recopying as with the computer.

Another contributing factor, which is similar to the point discussed above for Carver, is that, for whatever reason, students in the comparison classroom found the NAEP assessments particularly stimulating and therefore scored higher on them. We consider this explanation because the researcher who was present during the administration of the NAEP assessments in the Waverly comparison classroom reported an unusual level of excitement in that classroom about the assessments, and particularly over the final assessment stimulus, "The Key" (see description in Methods section).

Across all classrooms, LD students had a different level of performance than did non-LD students, and this difference was statistically significant. In Brown, where the treatment classroom exceeded the comparison classroom, and the LD students' rates of growth exceeded the growth rates of comparison LD students, the LD students were always performing less well than non-LD students. While the LD students did not "catch up" to their non-LD peers, even in Brown, the finding that the LD students' growth rates equalled that of their non-LD peers in Carver and Waverly and exceeded the growth rates of their non-LD peers in Brown is noteworthy. The review of research on LD students' writing in the Introduction pointed to the more usual situation, which is that LD students' performance begins to dive in relation to non-LD students' performance around the fourth and fifth grades.

Teachers frequently report that LD students' performance is more variable than that of non-LD students. In this study, this was not the case, for there were no significant differences between the two groups in the variability of scores on the NAEP assessment over the four points of assessment. Within the treatment and comparison classrooms, some LD students varied widely in performance from assessment to assessment, while others demonstrated a stable pattern of growth. And normally achieving students varied in this same way.

Because this research is "developmental"--still generating knowledge about the kinds of instruction and interventions that benefit LD writers, it will be important to look further at the variation within the LD group. Intensive observations of LD students, their writing samples and ongoing interviews with classroom and remedial teachers about the LD students in our treatment sample need a great deal of further analysis in order to illuminate the differences between the LD students who grew in the computer-supported writing classrooms and those who did not. For that analysis, we will be exploring several preliminary hypotheses about the interaction between specific LD writing problems and the writing tool.

One hypothesis, for example, is that students with extensive organizational problems will improve their ability to produce organized text when they are using the computer within a writing-process approach, but that those benefits will not transfer to paper-and-pencil writing situations, where the writing tool limits students' ability and motivation to reorganize the text. To be useful to mainstream classroom teachers with LD students, the research needs to go beyond the results addressed here to the identification of the specific instructional strategies--off and on the computer--that may benefit individual LD students. That analysis will be presented in forthcoming reports.

With regard to the absence of any impact of the computer-supported writing program on students' self-perception, it may be that the Harter scale measures psychological constructs that are relatively resistant to change. This may be particularly true when the intervention is only indirectly linked to the outcomes assessed in the self-perception measure. Even a child who perceives himself as improving his writing might not generalize his feelings of competence in this area to the more broad domains of academic achievement or global self-concept.

Another noteworthy set of findings concern the relationship between students' rate of growth in writing quality and their attitudes toward writing. In the site where computer-supported writing instruction had the greatest impact on students' writing quality and the site where it had the least impact, students also developed greater enjoyment of writing and increased their perception of themselves as "good" writers. In Carver, where treatment students achieved a high rate of growth in writing quality, fewer treatment than comparison students increased their perceptions of how good they are at writing. This result is difficult to interpret without more information about the students and the writing program in the comparison classroom.

While attitudes toward writing are important for all students, the relationship between attitudes toward writing and writing performance may be a subtle one. Students are not likely to write better simply because they believe they are good writers. On the other hand, students who identify with an "author" role and are reinforced continually for their communication abilities may be more willing to scrutinize their writing and be more accepting of the need to expand and revise their writing. They may be more willing to take advantage of revision instruction and opportunities. Positive attitudes may stimulate review and revision and therefore lead to better writing quality; those

attitudes may also be the result of students engaging in extended composing and revising activities and seeing their own writing grow and improve.

One of the more surprising findings from the student attitude questionnaire was that students in the computer-supported writing classrooms perceived themselves as writing less during the research year than did the students in the paper-and-pencil classrooms. Consistently, students using paper and pencil perceived themselves as writing more. Students in at least two of the computer-supported writing classrooms, Brown and Carver, were carrying out fewer writing assignments and expanding and revising their writing more over a longer period of time than were students in the comparison classrooms. In both of those classrooms, students were writing pieces of considerable lengths. Students' fairy tales in Carver were several pages in length and Brown students' autobiographies, written over several months, exceeded twenty pages in several instances. It may be that when students begin a new writing assignment on a weekly or bi-weekly basis, they feel they are in fact doing more writing than when they are continuing to elaborate or to rework the same piece over a longer period of time.

In conclusion, the results suggest that the computer may play a highly supportive role in certain kinds of writing instruction. Where students are working with longer pieces of writing over time, receiving ongoing instruction in the craft of writing and receiving specific appreciation and response to their writing from peers and the teacher, the computer may be an ideal writing tool. Writing becomes less a linear process of drafting, revising, and recopying than a series of encounters that can shift among elaborating, revising, and more mechanical levels of editing.

And while these results are encouraging, they should also alert teachers and administrators to the serious requirements of an effective computer-supported writing environment. Frequent access to computers on a one-to-one basis, training in machine skills and expert writing process instruction appear to be critical components of a well-implemented program. Even with those components in place, teachers still need considerable knowledge of the specific teaching and learning strategies that can maximize the benefits of the computer for special needs students. Continuing analysis of student case study data from the Writing Project may provide more of the specific tools and guidelines mainstream classroom teachers need, including ways to assess students' specific writing strengths and problems, strategies to promote generating, composing, revising and editing, and ways to promote teacher and peer conferencing with LD students.

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APPENDIX A
NAEP WRITING PROMPTS

When you come home from school one day, you find a key on the table. Beside the key is a note addressed to you. The note says:

This key unlocks something
very special and unusual.

Write a story about your adventures with this special key.

Here is a picture of some children on an overturned boat.
Write a story about these children on their day at the beach.

Here is a picture of an astronaut on the moon.

Write a story about an adventure that might happen on the moon.

16 minutes

36. When you come home from school one day, you find a flashlight on the table. Beside the flashlight is a note addressed to you. The note says:

> This is a flashlight with special powers. It is yours to use as you wish for only 24 hours. You will find out what those special powers are when you turn on the flashlight. Good luck!

Write a story about your adventures with this unusual flashlight.

Please continue on next

APPENDIX B
PRE AND POST STUDENT WRITING QUESTIONNAIRES

APPENDIX B

PRE AND POST STUDENT WRITING QUESIONNAIRES

EDC Writing Project - Student Questionnaire (Post)

Name_____ Date_____

Teacher_____

Please circle one answer for each question below.

1. Does your family have a computer at home? yes no

2. If yes, put a checkmark next to each activity you do on your home computer:
   _____ writing
   _____ programming (LOGO or BASIC)
   _____ playing games
   _____ other_____

3. How much do you enjoy using a computer?

   A LOT SOME NOT AT ALL

4. Not counting your homework, how much do you write at home?

   A LOT SOME NOT AT ALL

5. How much do you enjoy writing at home or in school?

   A LOT SOME NOT AT ALL

6. What kinds of writing do you like to do? Check as many as you like.
   _____ letters
   _____ imagining stories
   _____ diary or journal
   _____ stories about real events
   _____ reports
   _____ other_____

7. How good are you at writing?

   VERY GOOD PRETTY GOOD NOT VERY GOOD

8. What are the easy and hard parts of writing for you? Put a checkmark in the EASY ot HARD column for each part listed below.

	EASY	HARD	NOT SURE	DOES THE COMPUTER HELP YOU? (YES/NO)
a. thinking of an idea	_____	_____	_____	_____
b. planing what I want to write	_____	_____	_____	_____
c. writing my first draft	_____	_____	_____	_____
d. rereading my story and figuring out the changes I want to make	_____	_____	_____	_____
e. writing a second draft with any changes	_____	_____	_____	_____
f. editing my writing for spelling and punctuation	_____	_____	_____	_____
g. conferencing with a classmate about my writing	_____	_____	_____	_____
h. conferncing with my teacher about my writing	_____	_____	_____	_____
i. reading my writing to the class during class sharing time	_____	_____	_____	_____
j. spelling	_____	_____	_____	_____
k. punctuation and capitalization rules	_____	_____	_____	_____
l. handwriting	_____	_____	_____	_____

9. How much do you enjoy writing on a computer?

A LOT SOME NOT AT ALL

10. What do you like best about writing on a computer?

11. What do you like least about writing on a computer?

12. How has the computer helped your writing?

13. Would you rather write on the computer or with paper and pencil? Why?

EDC Writing Project - Student Questionnaire (Pre)

Name_____ Date_____

Teacher_____

Please circle one answer for each question below.

1. Does your family have a computer at home? yes no

2. If yes, put a checkmark next to each activity you do on your home computer:

   ____ writing

   ____ programming (LOGO or BASIC)

   ____ playing games

   ____ other_____

3. How much do you enjoy using a computer?

   A LOT SOME NOT AT ALL

4. Not counting your homework, how much do you write at home?

   A LOT SOME NOT AT ALL

5. How much do you enjoy writing at home or in school?

   A LOT SOME NOT AT ALL

6. What kinds of writing do you like to do? Check as many as you like.

   ____ letters

   ____ imaginary stories

   ____ diary or journal

   ____ stories about real events

   ____ reports

   ____ other_____

7. How good are you at writing?

   VERY GOOD PRETTY GOOD NOT VERY GOOD

Writing Project Questionnaire, Page 2.

Name_____

8. What are the easy and hard parts of writing for you? Put a checkmark in the EASY or HARD column for each part listed below.

	EASY	HARD	NOT SURE
a. thinking of an idea	____	____	____
b. planning what I want to write	____	____	____
c. writing my first draft	____	____	____
d. rereading my story and figuring out the changes I want to make	____	____	____
e. writing a second draft with my changes	____	____	____
f. editing my writing for spelling and punctuation	____	____	____
g. conferencing with a classmate about my writing	____	____	____
h. conferencing with my teacher about my writing	____	____	____
i. reading my writing to the class during class sharing time	____	____	____
j. spelling	____	____	____
k. punctuation and capitalization rules	____	____	____
l. handwriting	____	____	____

APPENDIX C
OBSERVATION PROCEDURE

APPENDIX C

OBSERVATION PROCEDURE

EDC WRITING PROJECT

11/09/87

STUDENT OBSERVATION PROCEDURES & GUIDELINES

Observation Focus

This year, we will focus our observations on the teacher and LD sample students. Our goal is to understand how LD students function in a writing process environment, documenting how they handle the demands of the writing task (in terms of the PROCESS and PRODUCT), the demands of the machine, and general learner demands. Our observation data should contribute to the individual student profiles we are developing. In addition, we are interested in highlighting problems/stumbling blocks and describing the strategies students and teachers use to overcome these stumbling blocks, including both successful and unsuccessful attempts.

Our observation of teachers will focus on how they introduce the lesson and interact with students during the writing session. We will highlight how and when teachers intervene to help students improve their writing, manage the writing process and become more effective learners. Again, we are interested in identifying strategies that help LD students.

We will not focus on the NA sample. but will include NA data through our observations of the teacher, detailing interactions with all students (sample and non-sample). This inclusion of NA data is important since it provides a context for our analysis of LD students.

Issue: We don't want students to become aware of our focus on the LD sample.

Possible strategies:

- At the end of each observation cycle, randomly select another student to observe for 30-60 seconds.
- When observing, position yourself between two students or somewhat at a distance, so that it is not obvious whom you are observing.
- At the beginning or end of class, talk to non-sample, as well as sample, students.
- Do not print out when students are present.

Observation Format

Heading

Site/Teacher _____ Date _____ Time _____
Observer _____
Setting (class/lab) _____
Activity _____ Module Used _____
Focal Student #1 _____
#2 _____
Other Adults _____
_____

General Procedures

Observation Cycle

-- During each session, alternately observe the teacher, focal student #1, and focal student #2.

-- Observe each person for approximately 3 minutes, extending it by 2 or 3 more minutes if warranted to document problem resolution.

-- The observation cycle proceeds as follows:

Class Intro
- Record teacher's introduction in detail (~ 1-10 min.)

Cycle 1
- Observe focal student #1 (~ 3 min.)
- Observe focal student #2 (~ 3 min.)
- Observe teacher (~ 3 min.)
- Observe NA student (~ 30-60 seconds)

Cycle 2
- Repeat cycle 1
- Observe class as a whole

Cycle 3
- Repeat cycle 1

Cycle 4 (may not be possible, depending on time)
- Repeat cycle 1
- Observe class as a whole

Class Closing
- Record teacher's closing in detail

Observation Notes

Record notes on left 2/3 of the paper, leaving a column on the right for coding.

Record teacher's introduction to the lesson

Teacher:

-- Describe teacher's directions in detail (for writing--relating to product and process; for the machine; and general environmental/behavior management issues).

-- Include variations for individual students.

Focal Students:

-- If a group lesson/discussion, is the student participating?

-- Does the student appear to be focused on the teacher's directions/lesson?

-- As evidenced by questions asked by the student or responses to teacher's questions, does the student understand what s/he is supposed to do?

-- At the end of the intro, does the student proceed to the next step easily?

Subject Observations

-- Record the beginning and ending time of each subject's observation.

-- Describe how the student is handling the writing/machine/other demands, identifying problems encountered and strategies used (both student and teacher generated).

-- Include interpretations or hypotheses, but identify them as such by enclosing them in parentheses.

-- Document any teacher or peer interaction.

Whole Class Observations

-- Every 20 to 30 minutes, stop and observe the class as a whole.

-- Record the time and briefly describe what is happening. Note how many are engaged in writing versus other activities.

Attend to Students' and Teacher's Performance in Relation to Four Areas:

-- Writing product

-- Writing process

-- Machine skills

-- Other (behavioral/environmental) demands

-- Student questions:
  - How is the student performing in each of the four areas?
  - What are the student's questions? problems? How are they resolved?
  - What are the student's strengths/successes in these four areas?
  - What works/doesn't work?

-- Teacher questions:
  - What are the teacher's instructional objectives?
  - How does s/he accomplish them?
  - What problems arise and how are they resolved?
  - What are particularly effective teaching strategies in the four areas?
  - What works/doesn't work?

Follow-Up Conversation with the Teacher

-- What activities preceded today's lesson?

-- What is planned next?

-- How did today's lesson go?
  - Things that succeeded/didn't succeed
  - Special concerns

Observation Write-Up

-- After the observation, review your notes.

-- Add details recalled about events observed.

-- Do a preliminary coding for the teacher(s) and students observed.
  - Focus on Writing Product
    Writing Process
    Machine Skills
    Other
  - Code each event, changing codes as the focus of the event changes. An event may have more than one coding.

-- Code problems (P) students are experiencing.
  - It may be the student is experiencing active difficulty or is not in compliance with the instructional task.

-- Feel free to adapt the coding to help answer our "questions of interest."

Observation Summary

Area Summary

-- Summarize each student's performance in each of the four areas.

-- Highlight problems and problem resolutions, as well as successes.

-- Some areas may require more of a discussion than others--don't recap everything in the observation.

-- Tally the codings for teacher and student.

General Comments

-- Overall, how is the class performing?

-- What appear to be differences between the LD and NA students?

Abbreviations

The following abbreviations may be used when recording observations:

	Word	Abbreviation
Machine Words	keyboard	kbd
	screen	scr
	read	rd
	typing	typ
	handwriting	hwritg
	delete	del
	insert	ins
	moving cursor	move-c
	save	sve
	print	prt
	retrieve	retve
	load	ld
Other Words	observer	obs
	conferencing	conf
	transition	tran

(Some of these may be difficult to remember--use whatever is most efficient.)

Student and Teacher Names

-- Use initials to identify individual students and teachers.

-- If you don't know the name of the student, write S1, S2, etc.

-- Be sure to include a legend to explain your codings.

-- Teachers' initials should be preceded by a T.

Example:

Legend: T = Tina, B = Bill, E = Eric
T-NC = Norma Cicarelli
T-MM = Marge Malano

APPENDIX D
NAEP IMAGINATIVE NARRATIVE SCORING GUIDE

APPENDIX D

NAEP IMAGINATIVE NARRATIVE SCORING GUIDE

FLASHLIGHT
N007600
Groups 1, 2, 3
Literary–Imaginative Narrative
(ID20)

WORK SCORING GUIDE

Primary Trait

Primary Trait: Invention of a narrative based on a given situation.

Scoring Rationale: The exercise calls for the creation of an imaginative narrative: "Write a story about your adventures." The subject and basic situation are given, and the writer must build an imaginative narrative that develops out of this situation.

0: No response (blank).

1: No storytelling. These responses do not show evidence of storytelling. They accumulate details without a situation to anchor or unite them, and they do not explicitly or implicitly tie the accumulation of details to the given situation of the flashlight, or they may simply reiterate the situation.

2: Minimal control of storytelling. These responses attempt the basic task of storytelling. They invent details that are explicitly tied to the given situation, but the demands of imaginative narrative are unfulfilled for one of several reasons: (1) the response may give the bare outline of a plot, with a beginning, middle, and end, but little or no elaboration of detail; (2) the response may have no sense of a plot, but may simply ramble on from the initial situation with many details, but with no process or purpose to give it point or structure (this type of response often sounds like a "wish list," a catalog of things that the writer would hope for if the flashlight could give the writer everything); (3) the response may begin telling a story, but never gets further than the beginning; and (4) the response may relate several stories without evident connection among them.

3: Satisfactory control of storytelling. These responses clearly show evidence of the storyteller's obligation to structure a plot and elaborate it with appropriate details. Thus they show a markedly greater sense of coherence with amplitude than "2" responses. But they are usually somewhat flawed in one of the following ways: (1) one or another part of the basic plot may be thinly or inconsistently detailed; (2) the situation may be established, the plot developed, but the piece may come to an end without appropriate closure; and (3) the plot may be completely elaborated, but it contains technical inconsistencies in point of view, handling of dialogue, or management of narration. In some way these stories set up expectations that they do not fulfill.

4: Fully controlled storytelling. These responses tell a complete story, amply as well as appropriately detailed at all points, and fully as well as consistently resolved.